THE
PRACTICAL MAGAZINE

NEW SERIES.—NO. 22. VOL. 6, 1876.

MARK FIRTH, ESQ., MAYOR OF SHEFFIELD (1875); WITH SOME NOTES ON SHEFFIELD.

SHEFFIELD and its surroundings constitute what is known to the general reader as Hallamshire, and in ancient days there is no doubt the Romans opened up iron works there, and probably were the first explorers of the mineral world in that district. Iron is mentioned by Strabo as one of the mineral productions, and in modern days there is the remarkable fact, that in the midst of a mass of scoria, the refuse of some ancient blomary, or puddling furnace—the place where iron ore is smelted and converted into steel—near Bradford was found a deposit of Roman coins. Steel making is an art of most remote antiquity, and its process was familiar to the conquerors before the Roman era. It was in all probability Alexander who introduced it into India when invading that vast region, and Indian steel has been made for ages from the Himalaya mountains to Cape Cormorin. The water in South Yorkshire has obvious traces in its colour of deep mineral wealth deposited in the great water reservoirs, whence emanate the springs; and that it lays near the surface is evident from the bright ochre tint of the streamlets which remain unpolluted by industrial operations, and there is now no tradition or record of iron works having existed. Over most of these beds of scoria the soil has accumulated to a thick crust, in which trees of very ancient growth are now flourishing. Even in the beautiful park have these relics of a long-past industry been found. Miners, puddlers, and smiths formed the staple industry, from which weapons of war, implements of husbandry, and domestic utensils issued for the supply of the inhabitants in that

prehistoric age. The earliest trace we have is in "Monastica Anglicanæ," where it is stated that the monks of Kirkstead established extensive iron works at Kimborworth :—

"Sounding caves
Of high Brigantium, where, by ruddy flames,
Vulcan's strong sons, with nervous arm, around
The steady anvil and the glaring mass,
Clattered their heavy anvils down by turns,
Flattening the steel."

Sheffield was remarkable among the clans, so to speak, of the English population, for rude intractable strength. They were of the clans, clannish; scorning to have communication with strangers, and refusing to all such a permanent residence among them. Their cutlery, &c., grew in repute, and none in England, and none abroad, could show superiority either in finish or temper. The master cutlers formed an organization as far back as the year 1300, and their trade had to endure many vicissitudes, and encounter most determined opposition. Nevertheless it became and remains the best market in the world. The enterprising Flemings, who claimed the monopoly of manufactures of several kinds, and by intercourse with whom several branches of the industrial arts have been advanced in their infant stages, exerted the utmost skill at their command in this steel department in hope of conquest. One distinguished foreign maker brought over some choice examples of his production, and on his arrival in England set to work to obtain orders. The master cutler went to see him, and, as they were in conversation, despatched a messenger to bring from his common stock some of his manufacture, which, on being tested, was found of superior quality to that of his rival. The Fleming found that in price and skill Sheffield could beat him out of the field.

Up to the last century all the goods continued to be made of wrought steel, but an ingenious clock-maker, Benjamin Hundsworth, discovered the art of making cast steel, and kept the secret many years, to his great profit. We have noticed his labours in a previous article—on Mr. H. Bessemer's process. Hundsworth set up a factory at Attercliffe, a village a few miles distant from Sheffield, but by the deceit and dishonesty of his people, the secret was divulged, and the inventor lost his all. As before stated, the Bessemer process has wrought a transformation in the trade. Cast steel of the finest qualities is readily made in huge masses, divested of all brittleness, and retaining the hardness, tenacity, toughness, and close texture necessary in producing sharp instruments.

King James granted a charter to Sheffield for a Cutler's Company, with a power of monopoly. This he states to have been bestowed in order to preserve the high character of the town for its steel manufactures, and to enable the corporation to maintain their repute by prohibiting all interlopers from practising the art there, and to secure remunerative prices by authorized trademarks already in use, but now to be a legalized protection to the master cutlers. Their hall was built in 1638, and rebuilt in 1726. The monopoly died out in 1814 by an Act of Parliament, which threw the trade open; but the best makers were permitted to keep and still retain their ancient corporation, which includes the firm of whom Mark Firth is the head, although their trade and manufactures include iron plates and steel guns. It also includes the great works of Cammell and John Brown; the principal in the former, Mr. Wilson, held the dignity of master cutler last year.[1]

The renown which Sheffield has in armour work is traditional. Before the introduction of modern cutlery an old ballad sings of a valiant hero :—

"But first he went new armour to
Bespeak in Sheffield town."

And another proves the independent bearing of these knife-makers and sword-workers:—

"I am a Sheffield blade, 'tis true,
Pray, what sort of a blade are you?"

At the beginning of this century Sheffield is well described in the newspaper which James Montgomery edited, "The Sheffield Iris," in a letter from a lad who had left college to take his place there:—

"Where sooty tops of clacking tilts arise[1]
Which heave their smoky volumes to the skies;
Where the red furnace boils with hollow roar
That melts to fiery wave the massy ore;
Where cheerful labour whistles o'er the wheel
Which smooths to keenest edge the stubborn steel;
'Twas in that mart of honest ancient fame—
How ancient, friend, let Chaucer's verse proclaim—
'Twas there, to form aright our tender youth,
Instruction mild first poured the light of truth."

Sheffield is one of the most distinguished examples of provincial prosperity, and the pride its natives have in their town is as honourable as it is jealously guarded. England learned with satisfaction the particulars of her grand display and welcome on the occasion of the visit of the Prince and Princess of Wales last year to dedicate to public uses one of the magnificent gifts of a Sheffield townsman, as an expression of his gratitude for personal success, and a mastering desire to leave in the place of his nativity and renown such blessings as shall last through all time.

Mark Firth had already built and endowed twelve almshouses at a cost of £30,000. He had presented a public hall for the evening recreation and the general service of the town, and he adds a deed of gift in perpetuity for the freehold of thirty-five acres as a recreation ground. Their Royal Highnesses became his guests for two days at his seat called Oakbrook, which is about six miles distant from the town. The public reception of the distinguished visitors will long be remembered as one of the most enthusiastic of the many loyal demonstrations accorded to the representatives of the Crown at provincial gatherings. The entire distance from the town to the mayor's residence was one chain of decoration of the most superb and tasteful character. His Grace of Norfolk, who owns the greater part of the soil, and whose title distinguishes the works of Mr. Firth (Norfolk Works), contributed an arch of most elaborate and characteristic construction, and processions of every class, bands of music, a mass, or rather an avenue, of 15,000 Sunday-school children, under that rare phenomenon in Sheffield, a fine sky, gave to the grimy old queen of Hallamshire all the dignity and glory of a new dress. The enthusiasm of Yorkshire made holiday for all the days of that week, amid vociferous hilarity and undoubted joy.

In the park, the Mayor, Mark Firth, addressed the Prince of Wales, on handing to His Royal Highness the deed of gift, by which he dedicates "Firth Park for ever to the public use and enjoyment of the people of Sheffield," in terms worthy of preservation, on account of their propriety, candour, and modesty. He said :—

"Raised by the favour of Almighty God to a position of comparative competency and prosperity, it has been my desire, in some public way, thankfully to acknowledge His goodness, and to make this acknowledgment in a form that should be serviceable throughout all time to as large a number of my fellow-townsmen as possible. Feeling a sincere interest in the welfare of my native town, and wishing to make some contribution to the means of recreation and enjoyment of its large and rapidly-increasing population, so many of whom are necessarily compelled to live in densely-inhabited streets, and to pass their days in crowded workshops, I have been unable to think of any mode by which my object could be better realized than by the gift of this park (thirty-five acres). I now beg to place in the hands of your Royal Highness the deed of gift of the park, with the devout and earnest wish that many among the present generation of my fellow-townsmen, and many in generations to come, may find within its borders recreation, enjoyment, and health."

To give an idea of the extent and magnitude of "The Norfolk Works," the ordinary description of the house will be sufficient. "Manufactures of cast-steel for rifled ordnance; shot, shell, rifle barrels, swords, bayonets, ramrods, tools, &c.; shear, German, and spring steel; cast-steel, straight, and crank axles, shafts, piston-rods, and general forgings for heavy shaftings; files, saws, and edge tools, &c.; manufacturers of puddled steel for shipbuilding, boiler-plates, &c."

A general description of the works of this firm is all we can supply. There may be seen the old-fashioned process of melting, which obtained from Swedish iron the finest steel, carried on in the most extensive manner known in England. Our readers will be able to recollect the notice of this process in the paper on Mr. Henry Bessemer's labours in our April number; and although that gentleman's inventions have, for general purposes,

[1] Trade-marks had an importance as legal evidence long ago. Buckingham was assassinated in 1626 by Felton, and the assassin left his knife in the body of the victim: that knife had upon it a company's mark showing it was made either in London or at Sheffield. The authorities sent to Sheffield at once, and the mark was identified as that of Thomas Wild, near High Street, and there still remain four firms connected with cutlery and steel in the town. Mr. Wild went to London as a witness for examination. He recognized the blade as one of two which he had made for Col. Felton, the recruiting officer then at Sheffield, and stated that he had been paid his price, tenpence. That evidence brought the charge home to the offender, and Wild's travelling expenses were paid.

[1] Tilt is the hammer-shop where the hammers were worked by water or steam-power.

practically superseded the ancient method, it is found that in the special department for which this house is pre-eminent, the old way must still be maintained—at least, for the present. The crucibles are arranged in rows sunk in the floor; they will only bear a repetition of their use three times, and consequently a crucible factory is a necessary adjunct to the works; for the demand is wholesale—400 at a time—and the material is bulky—pot clay and china clay suitably combined. Below this floor of holes and crucibles are vaults, in which the fire is kindled. The crucibles are then covered with hard coke, and left until the contents become fused. Steel cannot be made of a uniform mixture, because its use being for various purposes, the proportions of crude metal have to be also different, and hence the qualities in these crucibles have to be classified into Nos. 1, 2, 3, &c., when they come out in the ingot form, by being run into moulds, and thence placed aside for use. These ingots are of different sizes, ranging from 1 to 18 tons, which is the largest these works and that process have yet been able to produce.

The next department of chief interest is the gun-works, for which Firth & Sons are famous. There is seen the marvellous ease with which science can treat ponderous substances. There is as much difficulty in sending out a little as there is a large gun, and no more. The core of the 81-ton gun, lately removed from Woolwich to Shoeburyness, is the work of this firm. These cores, or solid blocks of steel, which are 25 ft. in length and 25 in. in diameter, are sent on to Woolwich to be jacketed, that is to say, hooped and rifled; but in the case of foreign orders for Continental governments, the guns are bored here and turned out complete, with the exception of the rifling. The place is an arsenal. When the Prince of Wales visited it in 1875, he saw the 81-ton gun in progress, and all sizes between down to the 7-pound howitzer. The boring instruments at work scoop out the interior of the solid steel block, and gradually cut the metal away in ribbon-like strips, by the use of machinery tools of still harder metal. Then the visitor is introduced to the hammer shop, where two of the famous and wonderful Nasmyth hammers are employed in forging the steel ingots into gun core. A crane takes up the enormous burden, swings it round to the front of a furnace, where one half of the ingot is thrust in, and there it remains until it becomes soft, and that is effected in about eighteen hours, more or less, according to the quality. When it is sufficiently malleable, the clips of the crane seize it, and the crane swings it round to the forging hammer. The power is derived from a head of steam being sent to the hammer-top to force it down, and give it extra striking weight. When it falls, the sparks fly, and the terrible concussion resounds through the whole works, and causes sensible vibration, though the blow descends upon a solid metal anvil. This anvil is a block that weighs 160 tons, resting upon a foundation of concrete and stone, an enormous product of the foundry cast close by, and requiring a period of three weeks to remove it the distance of 150 yards.

Of great distinction in Sheffield and famous throughout England is the establishment called the Cyclops Works (Messrs. Cammell & Sons), of which firm, as has been stated, Mr. Wilson, the late Master Cutler, is at the head. Here are huge vessels of molten steel handled like as wine or beer might be in making. Huge furnaces, that surpass those of our forefathers beyond imagination, are ever glowing, ever full, and ever flowing. Bessemer's magnificent and beneficial inventions characterize the whole series of buildings, wherein common iron has had to give way to fine steel, and at less cost than its predecessor. Those who desire to know at once the greatness, the rudeness, the refinements, and the elegancies proper to a first-class manufacturing town, can find no finer specimen in this island, or indeed in the world. The variety is very great, and quite beyond the length of this article to describe. For instance, the skill and enterprise engaged in the electro-plate manufacture is more than enough for a separate paper, and that we must altogether refrain from noticing. The sentiment of Englishmen was well expressed by the Prince of Wales at the Master Cutler's feast, on the last day of his visit to the mayor. He had at the Cyclops Works seen the manufacture of 20-in. thick iron plate; he had witnessed the doings of the planing machine, which cut up cold iron a quarter of an inch thick, as if it were cheese; he had seen the presses that had a 2,000-ton squeeze; and, addressing Mr. Wilson, the Master Cutler, mentioned the concentration of interest Sheffield specially possesses, spoke with extraordinary gratitude for his reception; recognized to the full the inherent democracy of the place, and paid a just tribute to the equally inherent loyalty of the inhabitants. He had seen the great works for which Sheffield was and ever will be celebrated, the vast engines of destruction and war, and the marvellous iron-plates for defence, besides inspecting the equally interesting cutlery works of the town. He tendered his entertainers his hearty thanks, together with those of the Princess, who shared with him the visit and who also shared his delight.

In addition to the ball which was given by the mayor (Mr. Firth) after the Cutler's Feast, which of course was at the cost of the Company, that gentleman added one more benefaction to the town after the Prince had left. The opening of the Universities to local students in the provinces necessitated certain provisions of buildings, libraries and apparatus in the great centres of the population, of which Sheffield is one. At a meeting in the following week Mr. Firth promised to provide at a cost of £15,000, a lecture-room and other buildings for that purpose, and challenged his fellow-townsmen to get up an endowment fund, towards which he would subscribe £1,000 if they would find £9,000. This was done, and Sheffield has ever reason to be proud, as many of her sister towns also are, of the affection of the children she has reared and trained in the way they should go.

We have only space to briefly note a few general observations on other departments of the Hallamshire industry; but we cannot dismiss the subject of Sheffield and its excellent men without due reference to its collateral manufactures. They are really staple, both in their service and result. Natural products depend for their appreciation on the service of man. They can become articles of use, comfort, or ornament; and a knowledge of their character and origin, when, by the invention or industry of man they become subject to him, is of great interest, and abounds in instruction.

First, of hair-cloth, which is woven from "tail-hair," imported from South America and Russia. This is subjected to a cleansing and bleaching process by lime or its chemical productions, and then boiled in logwood, blackened by copperas, and washed in river-water, when it is fit for dyeing. There are delicate colours and white; but in the production much technical care is necessary. The warp consists of dyed thread especially prepared, for the brightness and fastness of the colour of the fabric depends on the warp. Worsted and cotton are used, but linen is best. And it is a singular circumstance that the old hand-loom is the only machine adapted for its production; the modern machinery by steam is not available. These looms differ from the common ones in the shuttle and templet. The templet must keep the proper stretching strain upon the stuff, and consists of jaws with teeth made in a pincer-shape under a screw regulator, which draws or forces back the stuff as may be required. The woof is of hair, thrown with a hooked shuttle-rod of 3 feet in length made of box or other close-grained wood; and the operation is performed, for the most part, by children, under a weaver, who have their bundle of hair in water, and pass each one by one into the loom, and the weaver catches it and passes it through the warp until he has done his work, when, the pasting and varnishing and calendering being performed, the marketable goods are produced. This is essentially a Sheffield trade, for the only competitors are Paris and Worcester, and those are inferior. The weaver is generally a female, and some hundreds obtain employment in this industry.

Horns provide a fine material for the Sheffield trade; and the skill of the town in its application to manufacturing purposes is of the highest commercial value. Bulls have horns, and they are largely used, but the skill of the artizan finds its better field in the branching horns of the deer tribe, for in that budding, tree-like form he finds scope for the exercise of ingenuity which brings back a rich revenue. These natural, or rather animal products, are of infinite variety; no two are alike, except that every particle has a generic relation to the curvilinear form; and in the formation of handles to articles of cutlery and other purposes the workman finds a use for every inch of the raw material.

But the vast bulk of horn comes from the ox, and from all countries. It is a most valuable production, because of the facility and variety of its adaption to manufacturing purposes. As is well known, this kind of horn is only hardened cartilage, or indeed mucus, and hence some bird tribes yield a large quantity from their enormous beaks, and some fine white kinds are obtained from fishes. The Cape of Good Hope ships a large supply of ox horns of three feet in length, very large, and of singular perfection in their curve. Those from other countries, such as Sicily, are comparatively light and straight. But the Sheffield trade looks to Africa and India, and prefers the horn of the buffalo; these run six feet in length very frequently, and are of a material that yields with superior facility to the skill of the workman, whose duty it is to form handles to the Sheffield blades when all other divisions of labour have completed their tasks. Sheffield was the first place to utilize horn for handles of knives and forks: the first to discover the beauty it gave to their handy work by its shading, clouding, and colour. The tip of a horn is the best of all materials for a carving-knife; and with the riveting process the same horn that supplies the grasping

matter for the chief implement can furnish enough for all the rest of the set. Then there remained little slabs or veneers, which Sheffield was the first to use by riveting for the pocket clasp-knife of days gone by.

Horn is remarkable for its subserviency to the action of heat. Every one has seen a reading-glass, but few observe the construction of the rim thereof. You could not slice off a piece of horn and make a frame of that sort. These have to be sliced and boiled, and moulded so as to admit the introduction of the lens, and then by getting cool the horn contracts and is of permanent form, being glazed also in the process. The horn is first boiled, then subjected to a dry heat; it is then placed under a conical wedge, which descends like a monkey engine in pile-driving, and is partially forced open. It is then put between hot iron plates, and again pressed by the above force again and again, and the temperature gradually lowered, so that any thickness, from that of the comb to the transparent imitation of tortoise-shell, is produced. This is one of the most ancient of trade secrets, and has been practised in Sheffield for ages, but in these later times has developed into the production of many beautiful articles of the most delicate and graceful kind. A stranger who should visit Sheffield would find in this department a surprise. Horn is also remarkable for its amenity to pressure. We have but noticed it partially, but there is combined with this property the opportunity of giving pattern, colour, and gloss to articles produced from horn. The material is first sawn into proper sizes and boiled until flexible, it can then be cut with a knife to the capacity of the mould selected. These moulds contain polished steel dies of engraved patterns, and are kept hot. The bits of horn must be carefully cut so as to be just enough to fill the die when the pressure is applied. The dies are then brought close together, and by an immense pressure the horn is forced into every line of the engraved die, and when taken out is perfectly moulded and glossy. When the design is something better than a brush handle, the operation is twofold—the first makes a rough outline, the second the finished detail by means of two fitting dies. The further practical lesson is in the insertion of mother-of-pearl, jewels, monograms, or any other substance which, by ingenuity, will afford a most profitable and beautiful result. There is a vast market for this work, and although, through want of knowledge, and the inchoate appreciation of art, many errors and disappointments have occurred, there still remains a field of enterprise which Sheffield men and Sheffield enterprise can worthily turn to account. Horn is not adapted to outdoor purposes, and we cannot fly in the face of nature, although we love the melioration of art. Errors have arisen from exposing many things to the elements that, being of a vital and animal nature, cannot endure the test.

A word more about horns. It is curious to notice in all trades and manufactures which have to do with natural material—and that is an inclusive term, from which very few are exempt—how the factor classifies the goods. We have spoken of the branching form as full of applicability, but the Sheffield purchaser knows the difference between the buck-horn and the stag-horn, for those are the terms he employs in his dealings. The fallow-deer and its foreign representatives are in the first category, into which—not because of its solidity, for it is very light, but because of its beauty and the easiness of manipulation—is admitted the reindeer. The buck-horn finds its best market in Sheffield, for it is used for the handles of all knives of good metal, and cheap handles for butchers' blades and carving-knives. It gratifies the taste of Englishmen who love the associations of the animal world, and it is not of so costly a nature as to be beyond their means. But the Sheffield cutler looks to his stag-horn for the chief supplies of best handles. From it he gathers pen and pocket handles such as Joseph Rodgers and the Mappins use, and from it their best men get for the carver the knobby antler of everlasting variety. He can dye it; he can slice it; he can boil it; and when he saws it up, the dust and refuse is as valuable as the main buck. It is useful and beautiful, do what you will. We all know the value of *hartshorn:* go to Sheffield for the raw material. Every particle of the stag's antler is there manipulated to the very uttermost of advantage. Nothing is lost, and do what you please, elegance and service must result.

We must recognize also the utilization of bone in Sheffield, seeing that her blades were hafted with that substance from the beginning both in pocket and table-knives. The process is so far perfect that thousands of so-called ivory-handles are really bone. Certain breeds of oxen yield that substance in the purest white, and the utmost solidity. The facility with which it can be treated affords great variety in its application. It will take any colour, and is easily engraved or ornamented. The best and largest are cut into slabs and either drilled through or bound by rivets; the common, such as sheep's shanks, are used entire; the waste is made into all sorts of buttons.

Superior to bone in value and in artistic utility among Sheffield material is ivory. There was some time ago, and may be now in Messrs. Joseph Rodgers' show-rooms in Norfolk Street—that manufactory is about the best place in which to see the working up of this beautiful and useful substance—an elephant tusk 8 ft. in length, and weighing 146 pounds. That came from the East Indies; but the finest qualities are obtained from Africa, and are not so large. There is a purer colour in African ivory which the Sheffield buyers like. When it is first cut a delicate light brown tinge is seen, which, on exposure, changes to what the workman properly names a "blush." This formerly found a market among the opera-glass makers, and gave profitable employment to many artizans, but a change of fashion has occurred, and that kind of elegant manufacture has ceased to be what it was—a special item in Sheffield industries.

The last of these collateral branches that we can notice is the mother-of-pearl trade. This, as is well known, is the hard, silvery, brilliant, internal layer of several kinds of shells, chiefly that of the oyster. Those used in Sheffield are brought from India in bundles, in bamboo baskets, and in parcels of 1 cwt. to 120 lbs. Of course there is enormous waste when the manufacturer begins to work upon them. Some of these shells, however, are broad, flat, and thick, and good slabs can be cut from them; still the waste is very great. The artizan can boil horn, and by pressing make it flat; but he can do nothing with mother-of-pearl, except shiver it to pieces when he fails. Sometimes table-knife handles are cut out of solid pearl; but it is very rare, for the beauty of the substance is almost confined to the surface. The Sheffield makers have many devices for sawing, &c., and their familiarity with the hardening of steel stands them in good stead in making saws for cutting pearl; and they adapt also their perfection in grinding as well as cutting when bringing it into service. What is left when the cutler has done is sent off to the button maker in another part of the town, and shirts and collars all over the country give a good account of the result.

These notes have been necessarily discursive; but enough is said to show the characteristics and importance of the productions of Sheffield, and also of its public men.

W. S. C.

TOUGHENED GLASS:

NOTES ON ITS MANUFACTURE.[1]

THE following notes on the manufacture of toughened glass are the result of a visit to the factory at Choisy-le-Roi by M. Bourée. The process employed is that of De la Bastie. M. Bourée says that the result of the hardness of the glass being above all things a question of care, he enters into the details, it may seem, somewhat minutely; but he thinks it necessary in one who wishes to give an exact account of the process.

Theory of Toughness.—Toughness is a quality obtained by suddenly cooling a body after it has been heated. Glass is toughened by immersing it when red hot in a bath of a given temperature; that is to say, the glass, after having received its definite shape, instead of being placed in an oven where it gradually cools, after having gone through the operation of annealing, is, on the contrary, again heated to redness and rapidly plunged into a bath of grease. The toughness is the more effective in proportion to the excessiveness of the heat and the rapidity of the cooling. The cooling is obtained by the difference of the temperature of the glass at the moment of immersion and that of the bath. The effects of the toughening are purely physical. The toughening changes the molecular composition of the glass; it becomes less dense, and its fragments, when it is broken, do not contain sharp edges like ordinary glass. Pressed into the flesh it does not wound. This phenomenal metamorphosis will be accomplished under the better conditions the less of cohesion there is between the molecules. The more glass is malleable and approaches a pasty state, the more the molecules are easily displaced to group themselves after a certain law. Glass that has not been brought to a sufficient degree of malleability will be imperfectly toughened, and below a certain temperature will

[1] It should be borne in mind that the degrees of temperature referred to in this article are Centigrade—0° = 32° Fahrenheit. The word "toughened" is here employed, notwithstanding its possible faults of construction, as it has been adopted in this country as a denomination of the peculiar manufacture.

be insensible to the action of the bath; but if too soft it will be distorted. The glass to be submitted to the toughening process should be heated to a temperature approaching that which would alter its shape—nearly to melting. The more effectual the cooling the greater degree of toughness is attained; but the toughened glass breaks in a bath the temperature of which is too low. The reaction is too precipitate; the displacement of the molecules is produced in too accentuated a manner, and the equilibrium is broken. Within a certain limit the temperature of the bath is subservient to that of the glass. The minimum temperature of the bath in which the glass, heated almost to melting, is susceptible of being toughened must be found. It is to be found by experimenting, and varies:

1. With the composition of the glass.
2. With the form, the thickness, and the dimensions of the article.
3. With the temperature of the glass.

On the Influence of the Nature of the Glass on Toughening.—In accordance with its composition, glass approaching melting, and passing through its different states of malleability by very variable temperatures, the temperature of the bath should be also varied. Repeated experiments will best show. Primarily, it will be necessary to determine the temperature and the nature of the bath that is the most advisable for glass of which the exact composition is known. It may be said, in general, that the bath should be warmer in proportion to the softening of the glass being slower. Crystal: All crystal is toughened in a bath of pure grease in a temperature of from 60° to 120° Centigrade. Trials have been made with Baccarat crystal. A crystal composed of 300 parts of sand, 100 of potash and soda, and 50 of red lead, is one that succeeds well in toughening.

Glass: Glass is toughened in a mixture of oil and grease of a temperature varying from 150° to 300°; the more difficulty in melting the glass the higher the temperature employed. The proportions in which lime and soda enter into the composition notably influence the temperature of the bath. Bohemian glass, having a basis of potash, is toughened in a bath of at least 300°.

The Temperature of Crystal varies with the Thickness and Form of the Objects.—Shaped pieces of crystal coming from the same crucible, in accordance with their form, their thickness, and their dimensions, require to be more or less re-heated before being treated for toughening. The temperature of the bath should be also varied within certain limits. Thick pieces require to be re-heated the most, and want the bath a little hotter. Thus at Choisy-le-Roi gas tubes, lamp glasses, &c., are toughened in a bath of 60°; while drinking glasses and goblets, according to their form and dimensions, are toughened in baths reaching 60°, 65°, 70°, and 75°. Water-bottles, dishes, &c., are toughened in baths varying from 75° to 90°.

Composition of the Bath for Glass and Crystal.—The composition of the bath has a notable influence. All liquids are not appropriate for toughening. In water glass always breaks. Perfectly pure grease and virgin oil, free from all mixture, give the best results. Pure grease is employed for toughening crystal in preference to oil. Pieces toughened in oil attain clearness at much too great an expense. The toughening of glass requiring a bath of a temperature varying from 150° to 300°, pure grease cannot be employed on account of its ebullition. Recourse is therefore had to a mixture of three-fourths of linseed oil with one-fourth of grease. Pure glycerine, or a mixture of grease and glycerine, that will not boil up to 300°, may be employed with advantage in toughening glass. Toughening cannot be properly accomplished in a bath of grease that is not free from impurities or the least quantity of water. For this reason a new grease should not be employed that has not been previously heated for four or five days to a temperature of 150°. It can be used indefinitely afterwards, and the older it is the better. In a factory there should always be, in a fixed place, a constantly-heated vat of grease that would serve to replenish the baths. An indispensable condition for the success of the toughening is that the temperature of the glass should be perfectly uniform on all points of its surface.

Means of Conversion for Table-Glass.—Glass irregularly heated breaks in the bath, the toughening not being equal the equilibrium of the molecules is disturbed. In table-glass the object leaving the hands of the moulder has a nearly uniform temperature in all the points of its surface; it is always hotter at the extremity last fashioned, and re-heats more there. In this state it is not susceptible of receiving toughness; not being warm enough it should be replaced in the working-hole, and as deeply as possible, to insure the equal distribution of heat in all its points. In taking it out, the workman must assure himself, before plunging it in the bath, that this condition is fully realized. If the extreme parts appear redder than the others he will wipe them delicately with a piece of paper slightly wetted, and replace the piece in the working-hole for a few seconds before toughening. How long the glass should remain in the oven is for the workman to learn to determine. I will meanwhile say that a good workman toughens better with more heat. That piece which, brought to softening, would be deformed in unskilful hands, preserves, on the contrary, its form perfectly when confided to a trained toughener. It is important also that the temperature in the working-hole should be uniform. This is attained by heating it by burning wood equally distributed on the surface. Currents of air in the factory, which might cool the glass at the moment of toughening, must be carefully avoided.

Good management of the melting-ovens is of capital importance; the perfect homogeneity of the material is also one of the conditions of success. Glass that has remained a long time in the crucible, and that has thus maintained for too long an elevated temperature, tends to give way to a commencement of devitrification; in this state it will break in the bath. The work also should proceed rapidly and never be interrupted when it is desired to utilize the great part of the material contained in the crucible. A glass which presents a striated appearance—a defect likely to be produced if the management of the oven is not regular—will not adapt itself to toughening.

Apparatus for Toughening Table-Glass.—The grease-bath is contained in a cylindrical iron tub, placed on the floor of the factory, and as near as possible to the working-hole. This tub is 0·75 m. high and 0·60 m. in diameter. For convenience in carrying, the height should not exceed that of the opening of the working-hole above the ground. The capacity, limited by the necessity of being able to easily displace the tub in the factory, should be sufficient for it to contain and toughen during two or three consecutive hours pieces of the least dimensions. If the tubs are placed at a depth in the ground, and made to move upon rails in trenches, their capacity and depth may be increased and at the same time their displacement rendered more easy. It is necessary for this to have the working-holes heated by furnaces independent of those that contain the crucibles, to which access must be entirely free. In the tub is fitted a basket of 0·50 m. high and 0·55 m. in diameter; this lining, being a wire trellis of large mesh, is elastic, and sustained by iron braces. It is into these baskets that the glass is thrown at the moment of toughening.

Manner of Toughening Table-Glass.—The object being very uniformly heated, the workman takes it from the working-hole, plunges it rapidly into the bath, and after detaching it from the pontil by a slight blow on the side with a piece of wood, it falls to the bottom of the wire basket. This operation demands great supervision, and on the part of the workman much care and attention. There are numerous precautions in detail to observe to avoid the malformation of the glass at the moment of immersion. These precautions vary with the form of the pieces, and each of them is a study in itself. Different apparatus have been contrived to facilitate the operation.

A pouch of metal wire with a movable bottom is fixed inside the tub, and immersed from 0·30 m. to 0·35 m. in the liquid. Its use is to receive primarily those pieces which, by reason of their weight or of their form, might, by too brusque a fall, break the glass that is already at the bottom of the tub. There are some pieces, such as goblets, which are placed in the tub directly from the carrying rod without fear of breaking.

The toughening of water-bottles and similar vessels with necks presents a difficulty on account of the necessity of instantaneous introduction of the liquid into their interior. With the syphon a solution of this problem is found. The neck of the bottle is placed on the smaller branch of the syphon, which is elevated a half-centimetre above the surface of the bath. The confined air escapes by the tube, and the liquid takes its place, and at the same time, by a see-saw motion, the pieces fall to the bottom of the basket. A pump can be adapted to the syphon to extract the air from the bottle. By this means bottles with the narrowest of necks may be tempered. The toughening of objects made in several pieces has not hitherto been successful; the portions become detached in the bath.

Cooling, Cleansing, and Rinsing Toughened Crystal.—It is important to allow toughened crystal to gradually cool before removing it from the bath. To effect this, the tubs, placed on triangles, are removed from the working-hole and placed in a room in which a constant temperature of 40°—that of melting of grease—is maintained. In the course of four or five hours the baskets are taken from the tubs, and the pieces of glass taken out one by one and arranged to dry on sieves. The sieves are put into a stove, called the draining furnace, which is kept up to a temperature of 70°. In about two hours the glass is divested of the grease which had adhered to its sides. Taken from the stove, it is replaced in the large-mesh wire baskets, and these baskets are successively plunged into three reservoirs—the first containing a bath saturated with caustic soda, and heated to 60°,

the second containing water at 50°, the third, water of the temperature of the surrounding air. The glass, after it has been taken from the third reservoir, is perfectly rinsed; it is then dried, and taken to the warehouse, where it goes through a first sorting before being sent to the cutter. I will add here that toughened glass is cut and engraved more easily than ordinary glass.

When, instead of grease, a bath of oil is used, the pieces are allowed to cool longer before taking them to the tub; but the cleansing is much more expensive. They require to be treated with essence of turpentine.

Cost of Toughening Crystal.—The introduction of toughening into an existing glass-house is worked as follows for each furnace of three places:—1st. For staff, one more workman, called toughener, to each place; two porters to remove the tubs, and three men to take charge of the cleansing of the crystal. 2nd. For plant, four tubs to each place, each containing 170 to 180 litres of grease; two or three pouches, and as many syphons; three iron reservoirs, of a cubic metre capacity, for cleansing and rinsing; a number of sieves and baskets for carrying the glass to the cleansing reservoirs.

A tub for toughening, with its accessories, costs from 100 to 120 fr.; grease costs 120 fr. for 100 kilogrammes. For a melting furnace of three places, comprising six crucibles to four working-holes, the expense of toughening crystal will amount in a month of 26 days to the sum of about 2,200 fr. That is:—

	Fr.
Six tougheners, at 150 fr. a month	900
Two porters for tubs, at 130 fr. a month	260
Three men for cleaning, at 110 fr. to 120 fr. a month	350
Loss of grease by evaporation and in the manipulation of the glass	200
Fuel for the draining furnace, for the tubs for toughening and cleansing	100
Soda for cleansing	150
Wear and tear of apparatus and of the draining furnace, and interest on capital	250
Total	2,210

The loss occasioned by breaking and deformation of pieces in the bath is as yet of much importance, but every day will tend to diminish it with the improvements that may be brought to bear in the manner of toughening.

With these facts, knowing the exact number of pieces of the same model that can be made in a day's work, it will be easy to fix the price of the cost of toughening each object. Admitting 10 per cent. of loss and deformation, the price will be approximately:—

22-25 per cent. for goblets of all shapes.
30 „ for gas glasses.
40 „ for lamp glasses.
50 „ for lamp globes.

Glass costs more to toughen than crystal—the glass being toughened in oil, and at a higher temperature, the loss of the liquid from evaporation is more considerable, and the cleansing of the pieces more expensive. The cooling of the bath being also more slow, continuous work requires a greater number of tubs to each place. Instead of four there should be eight or ten. *Le Technologiste.*

WOOL DYEING.

A Course of Lectures: by George Jarmain.

THE third course of Cantor Lectures for the past Session had for its subject "Wool Dyeing," by Mr. George Jarmain; the first, which was delivered on Monday evening, March 6th, was as follows:—

Lecture I.

I have been instructed by the Council of the Society of Arts to give the present course of lectures on "Wool-dyeing," in order that students preparing for examination in this subject may have indicated to them the course of study which it is desirable for them to follow.

During the last twenty years, that is, since Mr. Perkin patented the process for the production of a mauve dye from aniline, in the year 1856, the woollen-dyeing trade has experienced great changes in the modes of performing many of its operations. The introduction of a large number of new dyes, through the discoveries of chemists, has necessitated these changes.

The dyer of the present day has, therefore, been educated to the fact that he owes a considerable number of his most beautiful colours to the chemist; and he has even received lessons in dyeing from him, for Schutzenberger and Lalande have taught the indigo dyer that he can dye a piece of cloth by other processes besides that of the woad vat.

The dyer has, in fact, received so many helps from the hands of the chemist, that it is difficult to understand why he does not more frequently endeavour to make himself acquainted with the principles of the science, which he must see is more competent than any other kind of knowledge to enable him to excel in his art.

Oftentimes, when I see the skill which, with long practice and observation, enables our working dyers to produce the excellent work which they turn out, I feel persuaded that were his practice and observation combined with correct scientific knowledge, the British working dyer need fear no rival which any country could produce. He would do well, however, to take to heart the fact that, however much practice he may have as a dyer, and however close his observation may have been, if he does not use the means to enable him fully to comprehend the nature of the operations which he is performing, he will, in the long run, be outstripped by those who have the good sense to combine theory and knowledge with practice.

On the other hand, the chemist is not always competent to give a satisfactory account of some of the ordinary processes of the dye-house, processes which seem to him but ill-adapted to accomplish the objects which the dyer has in view, but which, nevertheless, the dyer does accomplish.

Such being the case, it is very desirable that the chemist and the dyer should work hand in hand, and thus each in turn benefit the other.

Water.

This indispensable article claims our first attention. I may say that the success of the operations performed upon wool in the various processes of scouring, rinsing, bleaching, and dyeing will depend very much upon the character of the water employed. It is, therefore, of prime importance that the quality and suitability of the water for the operations intended to be carried on should be ascertained, before establishing new works or removing others already in operation.

Having had a large number and great variety of waters to examine from time to time, in order that their suitability for woollen manufacturing purposes might be ascertained, I have arrived at the following results, which I may term limits of impurity in water suitable for wool scouring and dyeing. The water must fulfil the following conditions:—

1. It must not exceed 7 degrees of hardness by Clark's soap test, of which it should not lose more than 2 degrees by boiling for an hour, and returning the water evaporated.

2. It must not deposit a brown sediment of oxide of iron when exposed freely to the air for some hours, nor must it give a blue coloration when a few drops of a solution of red prussiate of potash are added to a portion of it.

3. A portion of the water contained in a white glass bottle, to which a few drops of a solution of logwood are added, should be coloured of a sherry colour, which may be compared with a portion of distilled water treated in the same way.

4. The water should be clear, and must not throw up a brown scum of oxide of iron or organic matter when heated up to the boil.

5. Samples of wool or woollen fabric mordanted and dyed with the colours required, should compare well with similar samples mordanted and dyed with distilled water, or any other water known to be good.

A water which fulfils the above conditions is suitable for scouring and for the dyeing of woollen colours. Any considerable departure from these conditions will be attended with unsatisfactory results, unless the water be submitted to some treatment or purification.

The actual examination of the water is performed in the following manner:—

1.—*Clark's Soap Test.*

This test gives such abundant and important information to the scourer, dyer, and steam-user, that I venture to repeat such details of it that any intelligent operative may apply it to the examination of the waters in which he is most interested. The following are the apparatus and materials employed:—

One burette divided into 50 cubic centimetres, in $\frac{1}{5}$ or $\frac{1}{10}$ cubic centimetres, stoppered.
One stand and clamp to hold ditto.
One 100 cubic centimetre measure.
One stoppered bottle, about 16 ounces capacity.
One pint of soap test.

One 16-oz. flask, fitted with a perforated cork, through which passes a glass tube $\frac{1}{4}$-in. bore, and about 4 feet long.

One 3-in. funnel and filter paper.

One retort stand, with Bunsen burner or spirit lamp.

The soap test should be bought of an operative chemist, for it is somewhat troublesome to make. Directions for preparing it, however, may be found in many of our standard text-books of chemistry. The soap test consists of a solution of soap in dilute methylated spirit, of such a strength that, when shaken up with a definite quantity of the water, it will indicate the amount of soap-destroying materials or hardening matters contained in the water. The operation is performed in this way:—

Measure out 100 cubic centimetres of the water to be tested, and pour it into the clean and empty stoppered bottle.

Fix the burette in the clamp, and pour into it the soap test up to the top mark.

Run out the soap test through the glass stopper of the burette into the bottle containing the water, in small portions at a time, shaking the bottle vigorously after each addition; continue this operation until a full lather is formed on the surface of the water, which remains covered with the lather for five minutes.

When this point has been arrived at, read off the number of cubic centimetres which have been run out of the burette, and look for the degree of hardness in the table furnished by Dr. Clark, and which is here appended:—

Table showing the Degree of Hardness.

Degree of hardness.	Soap test measures.	Differences as for the next degree of hardness.
0	1·4	
1	3·2	1·8
2	5·4	2·2
3	7·6	2·2
4	9·6	2·0
5	11·6	2·0
6	13·6	2·0
7	15·6	2·0
8	17·5	1·9
9	19·4	1·9
10	21·3	1·9
11	23·1	1·8
12	24·9	1·8
13	26·7	1·8
14	28·5	1·8
15	30·3	1·7
16	32·0	

The first column gives the degree of hardness, the second the number of soap test measures, and the third is a useful number for determining the fractional part of the next degree—it is the denominator of a fraction, of which the excess above the number indicating the nearest whole degree is the numerator.

If, as sometimes happens, 32 measures of the soap test are insufficient to produce a lather, 50 cubic centimetres of the water are taken, and 50 cubic centimetres of distilled water added, and the hardness of the mixture is determined, the double of which is the true hardness of the water.

The hardness of the water, as determined above, represents the absolute or total hardness caused by the soap-destroying ingredients contained in it, which may consist of—bicarbonate of lime, bicarbonate of magnesia, bicarbonate of iron; sulphate of lime, sulphate of magnesia, sulphate of iron; chloride of calcium, chloride of magnesium; free acids, and acid salts.

The degrees of hardness are determined in terms of carbonate of lime or chalk, each degree representing one grain of carbonate of lime per gallon. If hardening matters other than carbonate of lime are the cause of the hardness, then they are present in the following approximative relative proportions, if the whole hardness be due to these bodies respectively:—

	Equivalents.
Carbonate of lime	100 parts.
„ magnesia	84 „
„ iron	116 „
Sulphate of lime (dry)	136 „
„ magnesia (dry)	120 „
„ iron „	152 „
Chloride of calcium	111 „
„ magnesium	95 „

That is to say, 100 lbs. of chalk dissolved in a certain bulk of water will make the water as hard as if it had dissolved in it 84 lbs. of carbonate of magnesia, 116 lbs. of carbonate of iron, and so on with the rest.

When water containing the bicarbonates in solution is boiled they are decomposed, carbonic acid being expelled, and they are converted into insoluble carbonates, which precipitate or form an incrustation on the vessel in which they are boiled.

It is often of great importance to the dyer and steam-user to know how much of the hardness of the water is due to the presence of these bicarbonates.

Proceed in this way:—Pour 100 cubic centimetres of the water into a clean flask fitted with a cork and a long straight tube. Boil gently for an hour, taking care that little or no steam escapes from the top of the tube; filter back into the measure, making the bulk up to 100 cubic centimetres with distilled water if necessary, then take the hardness with the soap test, with the precautions given above. The hardness thus obtained is due to the presence of bodies other than bicarbonates, and is called its "permanent" hardness, and the loss of hardness by the boiling is due to the removal of bicarbonates; the hardness so lost is called "temporary."

The following example will show how the results of an examination of water by the soap test should be calculated:—

A sample of water took 29·6 cubic centimetres to produce a persistent lather, and after boiling one hour and filtering it took only 7 cubic centimetres.

Therefore—

				Degrees.
Total hardness	= 28·5	=	14	= $14\frac{11}{18}$
	= 1·1	=	$\frac{11}{18}$	
Permanent do.	= 5·4	=	2	= $2\frac{8}{11}$
	= 1·6	=	$\frac{16}{22}$	
Temporary do.				
The difference or loss.	= -	=		12 nearly.

2.—Examination for Iron Compounds.

These form a very objectionable impurity; for many colours cannot be dyed satisfactorily if iron be contained in the water, even in small quantity. The iron is usually present in the water in the form of bicarbonate or sulphate of the protoxide (ferrous bicarbonate or sulphate), the former being the more frequent form. When the iron is present in appreciable quantity, its presence betrays itself by the water becoming turbid when exposed to the air in an open vessel, and, after a few hours, a reddish brown sediment is found at the bottom of the vessel, the water having more or less regained its clearness. The deposit consists of the iron converted into the condition of insoluble hydrated peroxide (ferric hydrate) by the oxidizing action of the air.

The iron may also be detected by adding a few drops of a solution of red prussiate of potash, which will give a blue coloration in such water. When present in small quantity, the iron may be found by boiling a portion of the water down to about one-tenth its bulk in a dish or flask; the iron, as peroxide, will then be found as a brown sediment, which may be dissolved in a little hydrochloric acid, and the above test applied to the solution.

3.—Examination with a Decoction of Logwood.

A decoction of logwood is an extremely delicate re-agent, showing by the various tints which it assumes the impurities contained in the water. The decoction is made by boiling about 1 oz. of logwood chips in 4 oz. of distilled water for a few minutes, allowing it to stand till quite cold, and then filtering it.

The water to be tested should be poured into the 100 cubic centimetres measure, or into a tall white glass bottle; a few drops of the infusion are then dropped into the water, and the coloration observed without stirring up the water.

The following reactions will be observed:—

Distilled water	A brown amber or sherry colour.
Water containing only—	
Calcic sulphate or chloride	Red amber, becoming red brown.
Magnesic do.	Amber, becoming more brown.
Calcic bicarbonate.	Red claret, passing to a bluer shade.
Magnesic do.	Red claret, becoming more blue.
Ferrous bicarbonate or sulphate.	Olive black, becoming blue black.
Alkaline carbonates, carbonate of potash or soda.	Dark cherry.
Free acids	Light amber.

The depth of coloration is, in each case, in proportion to the amount of the special impurity in solution. When there is a mixture of impurities, the coloration partakes also of a mixed character; but a departure from the standard of distilled water is readily recognized, and should not be considerable.

4.—*Organic Matter.*

The presence of organic matter in quantity which would prove injurious in the woollen industry, generally betrays itself by the brown coloration which it gives to the water, or by separating as a brown scum when the water is raised to the boil. This brown substance may, however, readily be mistaken for oxide of iron, which it frequently resembles very closely in colour. A portion of it should be removed, dried, and burnt; if it be organic matter it will burn almost completely away; if it be oxide of iron, a red powder will be left.

5.—*The Dyeing Test.*

To test the water, in order to ascertain whether it may be suitable for use for obtaining any particular colours, it is advisable to dye with it in a small way samples of the wool; at the same time, for comparison, samples should also be dyed, using distilled water or water known to be good for dyeing—taking every precaution to use in each case the same weight of materials and dyes, and the same temperature and time; and particular notice should be taken whether any marked change of colour takes place when the goods are finally rinsed or washed off in the same water.

The particular colours to be tried will readily suggest themselves to the dyer.

These small operations are best performed in an enamelled iron pan, heated over a powerful gas burner.

Having examined the water by the five operations described above, a good knowledge will have been obtained of its capabilities to fulfil the conditions required of it, and any obnoxious substances will have been detected.

Influence of the Impurities contained in Water on the Operations of Scouring, Rinsing, and Dyeing.

1.—*Calcareous and Magnesic Impurities.*

Influence on Scouring with Soap.—These impurities, in whatever form they may be present in the water, decompose and destroy as a detergent their equivalent quantities of soap, by converting it into a lime or magnesia soap, which is insoluble and greasy, and not only non-detergent, but it adds to the difficulty of the subsequent thorough cleansing. Every pound of chalk or carbonate of lime dissolved in water destroys 10 lbs. of soap. The insoluble soap so formed cannot be washed out from the wool or fabric, to which it attaches itself with great tenacity, and is frequently very mischievous in the dye-bath, producing irregularity in the reception of both mordant and dye. I have, therefore, mentioned 7 degrees of hardness as the furthest limit at which it will be found advisable to employ water for scouring purposes when soap has to be used.

Even during the rinsing or washing off the wool or fabric where soap has been used, the mischief is increased by the fresh water acting upon the excess of soap which has to be used to obtain a scour; this excess is also converted into insoluble soap, and is added to that already formed.

Influence on Scouring with Alkaline Carbonates and Urine.—Calcareous and magnesic salts, when heated up with alkaline carbonates, precipitate their carbonates in a powdery condition, which may readily be removed by washing; but as wool generally contains a portion of natural fatty matter which forms a soapy emulsion with the alkaline carbonate, the presence of calcic and magnesic compounds interferes with the detergent action of the alkalies. The bad effects, however, are not so great as when soap has to be employed for scouring.

Influence on Mordanting and Dyeing.—Calcic and magnesic salts, when in the condition of sulphates or chlorides, appear to have no influence over the reception of either mordant or dye; waters containing them act, so far as woollen dyeing is concerned, as pure water.

When the salts are in the condition of carbonates, held in solution by carbonic acid (so-called bi-carbonates), they are often exceedingly troublesome.

1. They diminish the effect of the mordant, and necessitate great care in counteracting this evil tendency by the use of an acid of tartar.

2. They produce a different shade of colour in most cases in the dye-bath, and require great skill and experience to obtain uniform results.

In fact, the dyer has a host of complaints to make against these earthy carbonates, for they blue his cochineal scarlets and purples; they blue the reds of his red woods; they strengthen the colours of logwood, fustic, and bark, but at the same time the colours loose their brightness, and the strength of colour is not permanent; they destroy his tartar, which expends itself in converting the earthy carbonates into tartrates; they act generally as a diminution of mordant.

2.—*Impurities in the form of Iron Salts (Ferruginous Waters).*

Their influence on Scouring.—With soap they act like the calcic and magnesic salts, producing an iron soap which adheres to the wool, and is more mischievous than even the lime and magnesia soaps, for it seriously affects the colours afterwards dyed upon the wool. With alkaline carbonates (soda ash, urine) the oxide or hydrate of iron is precipitated, which adheres more or less to the wool or fabric, and is a constant source of anxiety and annoyance to the dyer.

Their influence on Dyeing.—As iron compounds always have the effect of saddening colours, it is hopeless to expect to obtain any bright shades of colour when a ferruginous water is used. Even with the dark and sad shades, and blacks, the use of this description of water frequently produces unsatisfactory colours. I have often seen cloudy and rusty spots on pieces which have been dyed with such water.

3.—*Impurities in the form of Alkaline Carbonates.*

Influence on Scouring.—When the water is not also charged with earthy carbonates, the presence of these carbonates is beneficial rather than otherwise in scouring with either soap or alkaline carbonates.

Influence on Dyeing.—I know of no condition of water which is more troublesome to the dyer than this alkaline condition. In the mordanting it precipitates the bases of iron, tin, and copper salts, and of alum, and reduces bichromate of potash to the condition of yellow chromate, a much less effective mordant. It acts on mordants in a similar manner to what the earthy carbonates do, but the action is sharper and more decided. Its evil influence can only be prevented by the use of an acid to neutralize the alkalinity of the water.

In dyeing with this alkaline water the greatest care and skill are required, otherwise the colours will be affected; and in the rinsing or washing off, the colours, which may have been set right in the dye-bath, will be thrown altogether wrong again by the alkalinity of the wash-water.

I repeat, I know of no condition of water which is more perplexing to the dyer than this alkalinity; and, unfortunately, it is of too common occurrence in some of the woollen districts of Yorkshire, where the dyer derives his supply from wells, or by boring into the lower beds of the coal measures, which appear to be charged with carbonate of soda.

4.—*Organic Impurities.*

Waters charged with organic matters in sufficient quantity to give them a colour are not suitable for bleaching wool, as they tend to stain it; but I have not met with any cases in which they have proved prejudicial for scouring or dyeing, except the organic matter be in the form of dye-waters from other works. Even the peaty waters from our Yorkshire moorlands do not seem to have any prejudicial influence on the dyeing of wool or woollen fabric; at any rate, no cases have come under my notice.

5.—*Impurities in the form of Free Acids or Acid Salts.*

I have met with two classes of these waters:—(*a*) Waters containing peaty acids. (*b*) Water running from pyritic shales near the surface, which by oxidation charge the water with sulphate of iron. On exposure, much of the iron deposits, leaving the water acid with free sulphuric acid. Both these waters are exceedingly injurious to steam boilers. The acids become concentrated by evaporation in the steam boiler and attack the iron plates.

A new boiler, for which the first class of water was used, had its half-inch plates perforated after three months' use, and the tubes of a multitubular boiler had to be removed after using the second description of water for a few months. Both waters were entirely corrected by the addition of a little lime. They neither of them contained a trace of lime.

These waters are unsuitable for the treatment of wool. The second one decomposes soap and liberates the fatty acids contained in it, which attach themselves to the wool in the same manner as the lime and magnesia soaps which I have already described.

(*To be continued.*)

IMPROVED CARVING AND PANELLING MACHINE.

AMONG workers in wood there seems to be a growing demand for machinery which will effect a decrease in the waste of the raw material corresponding to its advancing cost, and enable them to utilize new methods of designing and working in wood in such a manner as further to lessen the expense of production. Among these new methods is that of panelling or carving mouldings in the solid wood, instead of producing them separately and attaching them to the article in course of manufacture. For this purpose special machines are being constructed.

The accompanying illustration is from a machine recently brought out by Messrs. J. A. Fay and Company, Cincinnati, Ohio. It is designed to produce carvings and recessed or relieved panels on the surface of wood, also for edge-moulding and ornamenting the edges of bracket and fret-work, &c., in a rapid and perfect manner. It is especially adapted for furniture, piano, and organ manufacturers, and other trades in which wood carving or fretwork is employed.

The machine is constructed on a hollow iron column, of a form to best meet the requirements of the working parts ; the neck being extended to support the cutter spindle over the centre of the table. The table is adjusted to the proper height, and regulated to form the desired depth of moulding or carving by a hand-wheel and screw. It has a sufficient movement to allow material up to four inches in thickness to be worked. The elevation of the table to bring the material in contact with the cutter is accomplished by a notched treadle, and its depression to remove the material by an auxiliary treadle, which disengages a pawl, allowing the table to fall to its original position.

The cutter is reversible in its motion, and is placed in a tapered split sleeve extending through the spindle, and fastened or released by a hand-wheel at the top. The reversible motion of the cutter is produced by the method of belting with a cross and straight belt, alternately shifting from a loose to the tight pulley as the nature of the work may require. The handle of the reversing lever is under the table, within easy reach of the operator, and is provided with stops to retain it in proper position.

In the operation of carving the pattern is placed over the piece to be worked, and guided by a fixed collar attached to the spindle, or a loose collar on the shank of the cutter. Any diameter of cutter can be used without altering the size of the guide collar. There being an opening between the pattern and the piece being carved, the cutter and its working are at all times in plain view of the operator.

Attached to the spindle is a fan-blower, which removes all dust in the contrary direction from the operator and keeps the surface of the work free from obstruction. The points claimed for the machine are that it is convenient, efficient, and durable, and that its comparatively low cost places it within reach of all who are in want of such a labour-saving machine.

MECHANICAL SCIENCE.[1]

IT is generally most useful and most interesting to intelligent listeners to hear from those who address them that which is the most familiar to the mind of the speaker. Passing by the question of primary education, I propose, therefore, to review briefly our shortcomings in those subjects of instruction which are the necessary preludes to natural, and especially to mechanical, science. I then propose to direct your attention to some points dependent on the crowding of the population, and especially to those consequences of it which are chiefly interesting to the section of mechanical science. To such an assembly as I see before me it hardly needs that I should say much on the importance of a wide-spread knowledge, as sound and exact as it can be made, of the nature of all things about us. We need this not only as a nation to compete with other nations, but we also need it more and more every day as men. The crowded condition of the earth at this day is in the strongest contrast to its state in the early days of our race ; and the necessities of our life then and now are in as strong contrast as those two conditions, or as the numbers who lived and live subject to them. Even in the early days there was more knowledge afoot than the thoughtless among us dream of. At no stage of man's history was life to be held on easy terms, and to

[1] An address by Charles W. Merrifield, F.R.S., President of the Section of Mechanical Science, delivered at the meeting of the British Association at Glasgow, September, 1876.

those who in early times neglected the knowledge necessary to take care of themselves and those about them, the penalty of their remissness was short and sure. It is not less certain now. Equal difficulties and dangers still beset us, and are to be met in the same way—by acquiring knowledge, and by applying it with industry and judgment. Only the knowledge that we want is greater now than then, and, being a higher development of knowledge, it requires to be more systematically learnt and taught. This is an absolute necessity to us if we wish to extend, or even to preserve, the possibility of our maintenance in such masses as are gathered together in Western Europe, and in such towns as London or Glasgow. Although the possibility of our existence as we are, has been the consequence of our ancestors, whether advisedly or not, yet successfully, following the law just indicated, it is one of the concomitants of their success that we have brought up amongst us the weak and foolish, who have received the benefit of the knowledge and industry of others without participating in either sufficiently to understand the conditions which have rendered possible an ignorant, an idle, or a vicious life. Just as the citizen of a country which has been over long at peace does not understand that his safety depends upon the fighting power of himself and of those who will take his part, so there are some in our midst who do not see the danger of ignorance or the waste of idleness. Those among us are perhaps few who do not recognize some disadvantage in ignorance and indolence; but there are, I fear, many who fail to realize the urgency of extirpating both to the uttermost. Let me not be misunderstood; I do not suggest that there should be no pause from learning or from exertion; life would not be worth having without its intervals of ease; but the enjoyment of these precious intervals is only to be purchased at the expense of habitual thought and exertion, and, in our present social condition, we cannot safely neglect to afford to all amongst us opportunities of cultivating observation and thought. These remarks may seem to you something like "slaying the dead." To those engaged in the active work of mechanical industry, ignorance, stupidity, and indolence are the enemy at the gate, with whom there is and can be no truce. But let me ask even you whether you have not among your circle of acquaintance many who think that the erudition of a few and the ignorance of the many is a better state of things than the universal and systematic instruction which, happily for ourselves, our representative assembly has now determined to secure for all amongst us. Let me ask whether there are not some who think the study of history or literature far more important than natural science; some also who think that religious teaching supersedes all other learning. All these doctrines are, in my opinion, false, and dangerous to society. I do not undervalue either religious teaching or historical knowledge. Of the former, this is not the place in which it would become me to speak, even were I its authorized exponent. Of the latter, it would be almost equally preposterous to speak slightingly. No one feels more keenly or practically than I do that the past is the key to the future, and that all our knowledge depends upon experience. Not only do I acknowledge this as an abstract truth, but I have myself constantly been driven to historical study before I could attain any real mastery of the work which lay before me in any of my pursuits, even of natural science. Moreover, my habits and instincts have a strong bias in that direction, my early education having been classical and legal, and my first actual employment having been in the archæology of painting. It is, therefore, with no prejudice against useful scholastic learning that I raise my voice against the misdirection of education. Still less is it with any prejudice against the exactness of the knowledge to be acquired.

Let us for a moment reflect upon what marks the difference between what we are pleased to call civilization and barbarism—what distinguishes the Anglo-American from the Red Indian, the Russian from the Tartar, the Western European and his colonial congeners from the races which he is governing or replacing. It is not, or at least assuredly not alone, by muscular superiority, nor is it by mere astuteness; the savage or the half-savage competes with us very favourably in both these respects. To emphasize the real difference let us go a little further back, and ask ourselves why the bear and the tiger are no longer a terror to us, and why we feel secure of the predominance of man, at any rate against the larger and fiercer of the dwellers in the earth, the water, and the air. This predominance is due solely to the command which our intellect has given us over the material powers of nature. Physical science has enabled us to set these against the mere unaided strength of brutes. Superior and more exact science has enabled the dominant races to bring more of these material forces to bear upon their enemies than the barbarous tribes could array against them. This is so universally admitted as a principle that its real application is often forgotten, and there are many who think that our civilization has in it something *sui generis*, some special innate principle which assures us against barbarian attack, instead of regarding it in its proper light, as merely one element of strength which may turn the balance in our favour, provided we are equally, or nearly equally, matched in other respects. But history is not wanting in terrible lessons of the utter destruction of civilized communities. Long-continued security and the accumulation of mechanical appliances carry with them and foster the seeds of social decay. These, perchance, are remote contingencies, although even to nations disaster comes unexpectedly. More immediate and more obvious risks are these: that we may be beaten by other nations, not in a struggle for bare existence, but in industrial competition, and that the crowded population which has to be maintained in these islands, and which former prosperity has accustomed to expensive habits of life, and not to the endurance of scarcity or hardship, may not find the means of exchanging its labour advantageously for the material of its sustenance; or that ignorance of the conditions of health, or inattention to its laws, may expose us to disease. Not all of us, I conjecture, have realized how much more difficult and costly it is to keep in prosperity and health the enormous agglomerations of humanity which Western Europe on the one hand, and China and India on the other, present to us, than to feed the scattered populations which occupy the less crowded regions of the globe. I think some of us are now beginning, at least, to understand that there are material difficulties in keeping any large collection of one group of animated life together, so that each individual shall not intercept or contaminate the sources of nourishment of himself or of others. Now what I wish you to reflect upon is, that these difficulties are material, and are therefore to be met by a thorough and wide-spread knowledge of natural science. With thin populations, which have more to fear from war and famine than from want of elbow-room, political and historical knowledge in the governing class is more important than exact natural knowledge in the administrative class. As the population thickens, the latter assumes more and more relative importance; and while I do not think political wisdom will ever lose any of its value, I think it only a part of that political wisdom to recognize that in such communities as ours the spread of natural science is of far more immediate urgency than any other secondary study. Whatever else he may know, viewed in the light of modern necessities, a man who is not fairly versed in exact science is only a half-educated man, and if he has substituted literature and history for natural science, he has chosen the less useful alternative. One of the obstacles to the spread of science, and to our national prosperity, then, I take to be the undue preference given to literary over natural knowledge, and, in particular, the sacrifice of mathematical to classical study in the secondary school. If you ask why I lay so much stress on mathematical teaching, my answer is that we need to study natural science exactly and quantitatively, not merely to cram our memory with the qualitative characters of a few phenomena. Now if we are to count, to measure, to weigh, or otherwise to ascertain quantity, we are really practising arithmetic, geometry, and mechanics. If we can learn these more advantageously than by the ordinary course of mathematical study, we shall simply change the form of that study without evading the thing. But in truth mathematics are too well understood, and on the whole too sensibly taught, to admit of any great subversions. Improvements in detail, and in the selection of the most useful branches for study, there is doubtless room for, and indeed these are being daily made. The chief faults I notice are in teaching algebra too late, and in teaching Euclid (so called) too early. I regard abstract geometry as a foolish study, unless accompanied, and even to a certain extent preceded, by the practice of linear drawing. This is too often neglected. Moreover I do not consider that what is called Euclid—I use this expression advisedly—is the best possible text-book for abstract geometry. I doubt if Euclid, if we judge him by the best Greek text handed down to us, is suited to our modern requirements. What we actually use, is not Euclid, but only isolated portions of his book, freely altered by Robert Simson. In my opinion, the omissions and alterations have deprived the book of all life-like vigour and human interest, and have made it as dull to the mature reader as it necessarily is to the unfortunate boys whose first introduction to geometry it too frequently forms. Apart from the general fault of giving too low a place to mathematical teaching—a great fault, and one which we are only slowly mending—is our not paying sufficient attention, and sufficiently early attention, to mechanical and geometrical drawing. On this point I need add but little to what was said by Professor Fleeming Jenkin in his address to this section at Edinburgh in 1871. That is possibly the point on which we compare least favourably with neighbouring countries. One important remark of his I am anxious to give prominence to, and that is, that descriptive geometry is not what is wanted. I fear, indeed, that many teachers of this subject have

failed to realize its true meaning, and confuse it with the theory of geometrical projection, of which it is in truth a development and extension, not a particular application. So far as the preliminary chapters of an elementary work on it are concerned, the confusion is natural, and perhaps not very material; for all that relates to the point and straight line is simply plan and elevation, and the plane needs but little more. But the characteristic feature of descriptive geometry is due to the fact that surfaces cannot (with the exception of cylindrical surfaces) be represented by plan and elevation. They are, therefore, in this science, *indicated* by a general and systematic method, which, without representing them to the eye, enables us to handle them geometrically, to find their intersections, their tangents, and their shadows, with the same certainty as if we had models before us. So far as points and lines, straight or curved, are concerned, it does not differ from geometrical projection: the difference is that it deals effectually with planes and curved surfaces, which geometrical projection cannot do. To those who have to deal with curved surfaces it is as important as linear drawing is to the student of plane geometry, because models are practically unprocurable, and conception in three dimensions is not easily got, except through descriptive geometry. But for ordinary school purposes it is a very barren exercise. I state this advisedly, being thoroughly familiar with both its use and abuse. A much more important exercise of geometry, and one more immediately useful, is the geometrical representation of arithmetic, such as we see in diagrams of thrust, pressure, speed, work, temperature, heat, rainfall, and so forth. But I think this will take care of itself, provided linear drawing be taught sufficiently early. I should leave my remarks incomplete if I did not make what you may at first sight think a digression, namely, some observations on our practice of teaching languages, especially Latin and Greek. But as they do form one side of education, and as we should be only half educated without them, it is important that they should be effectually and economically taught. And to none is this more important than to those who need to use them, but who can spare little time from their more essential study of natural science. I think all who value time will admit, if they allow themselves independent reflection on the subject, that Greek and Latin are taught too much as exercises of grammar and too little as languages. It is the same fault as we have had in mathematics, where making boys learn Euclid has been taken to be the same as teaching them geometry. Now teaching grammar and "construing" bear to language the same relation that drill does to marching and shooting, or that swimming on a table does to taking the water. In all these matters we have learnt that moderate drilling and plenty of work is the best combination; but we have not yet learnt this lesson in reference to the classics. Our ancestors had learnt and practised it. They spoke Latin in the schools, and to this the drill work of grammar and syntax was the proper complement. I hope you manage things better in Scotland, but in England it is the rule to spend from six to eight years in learning Latin and Greek, and it is the exception to be able to read either. If we cannot escape the effects of this scholastic tendency to exaggerate the importance of intellectual gymnastics over actual knowledge in classical and geometrical teaching, let us at least do our utmost to prevent its being extended to other languages and to other studies. There is a class which is exerting pressure in that way. I speak the more fearlessly on this subject, because, having most strongly advocated the extension of pure mathematics, I cannot possibly be mistaken for an objector to exact learning. Now, returning to the subject of mathematics, I think one cannot fail to be struck with the increasing tendency which they exhibit to pervade all study of natural science. I need not ask you whether it is wanted for mechanics. In the older books on chemistry, electricity, and so forth, it was quite an unusual thing to meet with an algebraic formula or a geometrical theorem. Now, on the contrary, we find that one-half of chemistry is pure algebra; organic chemistry, in particular, is nothing but a special branch of algebra coupled with the experimental—I had almost said accidental—fact that its formulæ are represented by actual combinations. This disguised algebra enters so largely into chemical teaching, that I have seen full marks obtained in an elementary examination paper on chemistry by students who really knew nothing of the science, but who did understand algebra well. I have recently seen a great deal of scientific work passing through the press, and I have been much struck by the way in which pure mathematics continually present themselves in all branches of knowledge. The reason is not far to seek. We have passed the merely descriptive stages of knowledge in most sciences, and when we come to quantitative study—that is to say, to discuss number, measure, position, and force—we are using mathematics, whether we know it and choose to call it so or not. Moreover, so far as we at present know, ordinary mathematics are the simplest ways of counting and measuring. I may mention, incidentally, that I think there are evidences that mathematical knowledge is spreading in many directions. Apart from what is doing in the universities and high schools, I have myself had an opportunity of observing it elsewhere, as the Examiner for elementary pure mathematics for the Science and Art Department. This year, in particular, I am able to say that there has been a very marked improvement in the knowledge of the candidates under examination, and I think the teaching of the science classes under the Department is really beginning to tell in this important subject. Compared with the requirements of this country, it is but a small matter, for there are only about 7,000 candidates annually, and these candidates come up more than once. Nevertheless it is good, so far as it goes, and I hope to see a great extension of the instruction in this as well as in other directions.

Assuming the possession of a certain amount of knowledge, which is now all but universally spread, the only real difficulty of a thin population in a temperate climate, is the protection of life and property. That assured, they can without difficulty supply their material wants in the way of animal and vegetable food, and of clothing. A very little, and generally a very easy, selection ensures a sufficiently pure water supply. Moderate cleanliness will secure sweet air in the houses, and, except in the fens or in certain valleys, there is always pure air out of doors. I do not assert that these conditions always exist in sparsely peopled countries; it is sufficient that they may, and sometimes do, exist. Insecurity first, and therewith scarcity of food, have been sufficient causes in most countries and in most times to compel aggregation. Towns, and even large cities, are quite as much a consequence of barbarism as of civilization. The real problem of civilization has been to render life tolerable in such aggregations, and that problem is only yet partially solved. We shall see by-and-by that it is now presented to us in a new and very troublesome form. It has always been a very difficult question, and the sacrifice of life due to its imperfect solution has been enormous, and is still large. Among the difficulties of town life I reckon chiefly: 1. The insufficient supply of fresh air, whether from overcrowding within the houses, or from narrowness or unwholesomeness of the streets. 2. The mere proximity of individuals facilitating the spread of contagious or infectious disease. 3. The getting rid of excreta or waste products. 4. A wholesome water supply to be provided and kept pure.

Of overcrowding I need not say much here: the circumstances which determine that are the concern of Section F rather than of the Mechanical Section. In this country, at least, it does not fall to the engineer to plan new cities in the wilderness. What he can do is to palliate the effects of overcrowding by supplying the means of ventilation and cleanliness. I do not now propose to entangle myself in the great and complex problem of ventilation; yet it is well not to pass one or two points unnoticed. It is rather difficult to say what pure air is. So far as health is concerned, the wind off the sea or the mountain is pure, or as good as pure. Whether the east wind be so or not is an open question. I suspect that its unpleasant character is due more to its dryness, and consequently to its chilling effect—an effect quite independent of its temperature—than to any actual contamination. Meat and milk, at any rate, will keep good with an east wind at least as well as with a west wind. However this may be, we are all sensible that when we are to leeward of a large town, the wind smells of the town. Not to mention factories and unsavoury trades, one day it has passed over miles of hot roofs and walls, and streets of unclean dust; another day the rain or the water-carts have converted miles of street into a reeking slough, compared with which a natural fen is a cleanly thing. In any case, we know and feel that we are breathing the waste products of human industry and of human life, to the detriment of our vitality as well as to the offence of our nostrils. I do not think sufficient attention has been paid to the mischief which may arise from copious watering unaccompanied by careful scavenging. We all know what town mud consists of; its wholesomest element being probably what makes it look the worst, namely, soot. In London there are hundreds of acres of mud and dirt kept almost constantly moist, by rain when there is any, and by water-carts when there is not. Now it seems to me that, merely looking at it from a broad, general point of view, this is not likely to be healthy; it seems to combine all the conditions necessary to the carrying on of unhealthy putrefactive and vegetative processes on a very extensive scale. I do not pretend to estimate the quantitative effect of this as an element of disease; but I think it would be making a large demand on your faith as well as mine to ask you to doubt its qualitative effect. At any rate, I think we ought to consider very seriously whether mere watering is any proper substitute for careful and complete scavenging, and whether, in fact, we are

not spoiling a useful process by an unintelligent application of it—one of the great dangers of improvement. The second point which I have mentioned—the facilitation of contagious or infectious disease by mere proximity—is obvious enough in its generality. Its details belong to Section D. The atmosphere is probably a much greater carrier of noxious germs than water; but, as Dr. Tyndall has judiciously remarked, the aerial germs appear to be sometimes in a less forward, and sometimes, perhaps, in a more effete, state of development, than those which are met with in water, or which have once taken root upon moist tissues. On the average, therefore, resistance to them is probably easier. However this may be, it is clear that we cannot subject the supply of atmospheric air which is necessary for our lungs and skin to the same complete chemical or mechanical treatment as we can, and do when necessary, our supply of drinking water. Any attempt at the disinfection of air of doubtful purity must necessarily be of the crudest and most empirical kind. In the present state of our knowledge and resources it can hardly be of interest to the engineer. The third point affords a remarkable example of what I have just mentioned as the greatest danger of all improvements—their unintelligent use. No one can deny that the water-closet and the sewer are great mechanical improvements; yet they have been great carriers of disease. As applied to the particular problem of getting rid of waste products, especially solid products, I do not think they were any improvement at all on much that we already had. In many towns in Great Britain, where there previously existed a well-understood and well-carried out scavenging system, I think they have done more in saving trouble than in conducing to health. I think the real key to the problem of getting rid of the nuisance of waste products is to be found in the old aphorism that *dirt is simply matter out of place*. Hence the first step is to take care that such products shall not become waste, and one condition of this is that they should not be carelessly mixed. The greater part of the sewage difficulty is, I think, simply the result of neglecting this truth. It is especially the case with London sewage. With our water supply, our water-closet system in houses, our drainage of houses, factories, and streets all together, we have accumulated a river of filth, the complex admixture and enormous mass of which have rendered it most difficult and dangerous to control effectually. I think we shall yet be driven to meet the difficulty at its source in the way suggested: by dealing with it in detail, subdividing both from house to house and from kind to kind, and allowing nothing but the mere washings of the streets to get into our sewers at all. So far as the getting rid of waste products is concerned, I believe we must be content to write off the whole cost of our metropolitan main drainage.

There is another undoubted improvement, which the Legislature has decided upon applying to London, concerning which I feel no small amount of misgiving lest it should be applied without intelligence, and that is the constant supply of water, in place of the intermittent cistern supply. As a mere mechanical convenience it will be a very great improvement; but I foresee two dangers, one of sewage contamination through the water-closets, the other of the waste of an article already becoming scarce. The first is no idle fear. The experience of Croydon and other places has shown that it is possible to make the water supply and the sewage a circulating system, with fever or cholera as its inevitable consequence. It has been bad enough in several places of moderate size; but in London, whether we regard it with reference to the mass of contaminating material, or to the quantity of human life to be affected by it, the risk has a much more serious aspect. I shall be sorry to see the constant supply established in London without taking some effectual security, either by the interposition of cisterns or otherwise, to prevent the possibility of back-draught from the cess to the drinking water. Without some such precaution I think the mechanical improvement may be a fatal gift. I have said that the problem of the crowd—if I may venture so to call that of maintaining purity in the supply of a dense population—is now presenting itself in a new and very difficult form. That is so notably in the matter of water supply, because until now it has generally been possible, by some expenditure in aqueducts and care in the selection of the sources, to obtain a sufficient supply of thoroughly good water, not always, perhaps, of chemical purity, but at any rate free from any great contamination of animal, and especially of human excreta. This possibility threatens to disappear in the United Kingdom generally, and especially so with regard to the manufacturing districts and to the east of England, not only from the mere increase of the population, but much more from the higher cultivation of the land. The moorlands are everywhere being broken up for the plough; fallowing has given place to heavy manuring and to sewage irrigation, both of which are freely applied to pasture as well as to arable land. The population of bullocks and sheep has also increased with the human population. The result is that the rain is contaminated as soon as it reaches the ground; the surface drainage, instead of being water naturally distilled, flowing off clean grass or moss, is the washings of manure. The spring water, again, is not pure rain water which has passed through a rock filter and has taken up some mineral ingredients, but is simply these manure washings more or less completely filtered. In our streams the water derived from both these sources undergoes fresh exposure and cleansing by aquatic vegetation, but at the same time fresh contamination. The mere statement of the problem in this way carries with it, almost axiomatically, the inference that the effective character of filtration is a matter for quantitative investigation, not for assumption as perfect and complete. We know, moreover, that some of these natural filters have been overtasked.

Let us now turn aside to consider what is the work to be done, and what is, so far as we are able to understand it, the work actually done by filtration. I believe I am right in saying that, with the exception of the strong corrosives, which act like weapons rather than as medicaments, no one really knows what poisoning is. We must take it as an expression used to summarize the unknown and possibly inscrutable chain of events, of which we only see the primary cause and the ultimate effect. We may, perhaps, go one step farther in respect of the poisonous effect of organic sewage in its unfiltered form. It contains, for one thing, the dead products of organic decay. A grass filter or an earth filter very rapidly renders this part of the sewage innocuous by oxidizing it. Then it contains germs of animal life, some of which, unless intercepted or killed, prey parasitically on the larger mammalia. Thirdly, it contains vegetable germs, closely allied, it would seem, to the moulds and other small fungi. These, finding a fit resting-place in our bodies, grow and destroy or spoil the cells of which our own growth consists, much in the same way that the yeast fungus modifies the worts of beer, or that the common mould spoils the flavour of a pot of jam. The effect of such spores upon us is called zymotic disease. The first class of impurities is pretty easily dealt with. Probably the means already exist of calculating at what point any given filter will, or will not, be overcharged in respect of its defecating function by the oxidation or entanglement of dead matter. But the question of the filtration of living germs is altogether more obscure. We know that many of them are caught and effectually intercepted by both surface and underground filtration; but we do not know in what proportion this intercepting takes place, either on the average of all germs or with reference to each kind of germ which may be present—different questions, not always sufficiently distinguished. Then we also know that the life of some germs is destroyed if their development be too long retarded. Bateman, Michael Scott, and others afterwards, have described the remarkable effect which storing water in dark tanks has in keeping it clear, not only while it remains in darkness, but even under subsequent exposure to light. Now, we have at present very little quantitative or well-digested knowledge on these subjects. In fact, little more is known of them than is contained in the crude statement which I have just laid before you. We have no series of experiments to show what or how many germs escape a given process of filtration or storage, and it is not every germ that we need be afraid of; the greater part of them, probably, are quite innocuous. All that the chemists have been able to give us is a dubious estimate of the total quantity of organic matter (whatever that term may mean) which the influent and effluent waters severally contain. They do not and cannot tell us in what form the matter exists, whether dead or alive, animal or fungoid. Now, for many purposes, the information so given is about as useful as it would be to know that there is animal and vegetable life in a given field, without being told whether it is corn or couch grass, rats or rabbits. On this subject I think both the engineer and the chemist will but grope in the dark until the biologist comes to their aid, working statistically with his microscope, as well as observing particular developments. Whether any observers are yet prepared by preliminary knowledge for such investigations, I know not, but sure I am that the need of them has come.

It may be some consolation to the timid or fastidious among my listeners to be assured, first, that only a few organic germs are capable of hurting us, and secondly, that an overwhelming proportion of the germs of life perishes without reaching maturity or attaining the power of doing mischief. This destruction goes on to an extent little dreamt of, except by those who have minutely examined the question. It is not an exaggeration, but in many cases an understatement, to say that a million germs are produced in most of the lower forms of life for one which ever reaches the reproductive stage in its turn.

Numerical evidence is easily obtained of this in the case of ferns and lycopodiums and fungi among plants, and of many worms and fishes and other creatures of lower organization among animals. This constitutes at the same time our safeguard and our danger—a safeguard, by the improbability of our meeting the few survivors of this enormous destruction; a danger, from their rapid increase when they do happen to meet with a resting-place favourable to their development. What is practically becoming most essential to us just now is to be able to pass from vague generalities, such as these, to definite and quantitative statements. No doubt much may be done, and is daily being done, to come to the assistance of these natural processes of purification by submitting water of doubtful quality to various operations, calculated either to remove certain classes of impurity, or to avoid clogging or otherwise overtasking the natural or other filters. But at present we are working in the dark, and empirically; in fact, applying quack remedies at random, instead of setting to work systematically and intelligently. Much fuller knowledge must be acquired before we can understand our business. In the meanwhile, I think that we must view with great and increasing distrust all merely selective sources of water supply, and, except perhaps in some favoured localities, such as the best of the gathering grounds from which Glasgow is happily supplied, we must not put too implicit confidence in any methods of filtration or boring. Besides, then, the general investigation which I have just spoken of, there remain two alternatives to consider, each of daily increasing importance in certain localities. One is the separation of the drinking from the ordinary supply, the other is the distillation of the drinking water. Neither of these is new, and there are many places where they are of obvious necessity, and practised with the greatest care accordingly. I think both require more attention than they have received in this country. As regards the separation of supply, it surely is not seemly that where there is no scarcity of water, but only a scarcity of wholesome water, the water-closets and factories and condensers of steam engines should be put in competition with the dry throats of the people for the drinkable supply. The question of distillation also requires further study. There seems to be no doubt that by subjecting water to sufficient heat we can destroy every living germ in it, and that by distillation we may combine this with the removal of almost all inorganic matter. At present the process seems to be rather expensive, and brings it up to a price which is far too high for its general use. But I think that when the process comes to be carefully gone into, with a view to working it upon a very large scale, it may not be found impossible to effect a considerable saving upon this cost. In fact, the mere necessity of delivering the distilled water at as low a temperature as possible, without the use of too much cooling material, is a security for the employment of as little coal as possible. We should require a settlement with the Excise to prevent the revenue suffering by fraud; but no doubt a compromise could be arrived at if the necessity were felt to be urgent.

The collection and arrangement of my thoughts, with a view to the remarks just addressed to you, has brought before my mind very strongly certain considerations, some of which, being partly of a political character, I shall rather indicate than discuss. In the first place, there is an evident and urgent necessity for the whole question of the water supply, at any rate of England, being much more thoroughly investigated and taken in hand than has hitherto been thought necessary. Secondly, there is need for the concentration of the business of the supply and distribution of water (including frequently the management of the gathering grounds), the roads, the lighting, and the drainage in one board for each town or district, preferably the municipal authority. In London, where there is no such concentration, the waste and inconvenience arising from the independence of the road, gas, and water authorities in the mere matter of breaking up the roads is becoming a very serious consideration. Thirdly, there is a want of knowledge of natural science in the local governing bodies, which is but ill-supplied by their employment of professional officers. Much more of it is wanted in the governing councils themselves before their technical advisers can be either properly appreciated or properly controlled. Whether this is to be got by the direct infusion of a professional element into the council itself, or whether it is best to wait for the general spread of natural knowledge, I scarcely care even to form a judgment. Fourthly, it is a popular delusion, especially prevalent in this section, that the invention and provision of a mechanical convenience is necessarily an immediate social benefit. There are many cases in which the direct effect is to facilitate personal indolence or carelessness. It is then a positive evil until, either by natural selection or by experience, more careful habits have been reverted to. There are other cases in which the indirect consequences are more mischievous than the direct advantages are beneficial. Here again there is no benefit until those consequences have been met. This is a disadvantage which only attaches to the immediate effects of some particular inventions. On the whole, of course, invention is not only a good thing, but, together with discovery, a necessity of our nature and of our existence. Meanwhile our immediate national necessity is a wider, deeper, more exact, and more general spread of natural knowledge.

TESTING FOR WATER IN COALS.[1]

By Mr. J. Blodget Britton.

SIX different samples of anthracite, each a firm, compact lump, were finely pulverized and immediately put in bottles. Portions of these were weighed and placed upon an ordinary water bath and dried for one hour, the average loss was 1·24. The same portions were then placed in a hot-air oven, and for two hours kept at a temperature of 285° Fah., and, after cooling in a dry chamber, were again weighed, when there was found a further average loss of 1·22, making a total so far of 2·46. They were then immediately returned to the oven, and for two hours more kept at a temperature of 530° Fah., and cooled and weighed again, when no further loss was found, but an average gain of ·55 upon the previous weighing. The same portions were a third time placed in the oven, and for about ten minutes kept at the last-mentioned temperature, and then, while still hot, were poured into ¼-inch glass tubes, each with a bulb at one end, and tested over a Bunsen burner at a temperature below a red heat, when more water vaporized and condensed in small clear globules at the cold parts of the tubes.

Fresh portions of the coal were then taken, and the total amount of water determined, and the average was found to be 3·04, or 1·80 more than was found at the temperature of the water bath, which was perhaps a little below 212° Fah. and ·58 more than the test of 285° Fah.

Tests were afterwards made by placing other fresh portions of the coal within a bell glass over strong sulphuric acid for more than twenty-six hours, when the total average loss was found to be 1·91, or 1·13 below the amount of water actually present in the coals. Upon allowing some of these last portions to remain in the open air for a couple of hours, they were found to have nearly regained their original weights. Additional fresh portions were then weighed, and left exposed to the open air of the laboratory, the next day they were weighed again and found to have gained an average of 1·03. This gain proved to be due almost entirely to moisture absorbed.

A sample of bituminous coal from Clearfield County, Pennsylvania, was treated very nearly in the same manner. Dried on the water bath for one hour it lost 1·69; dried in the hot-air oven for one hour at 250° Fah. the loss was less, being 1·65, and for another hour at 280° Fah. the loss remained nearly the same, 1·66. Being a third time returned to the oven and kept for about two hours at 580° Fah. the loss was increased to 2·14. The coal was then tested in a bulb tube over a Bunsen burner at below a red heat, and the presence of water was distinctly detected. The actual amount of water in the sample was subsequently found to be 2·46, or ·77 more than the loss at the temperature of the water bath, and ·32 more than at the temperature of 530° Fah.

Another sample of bituminous coal from Huntingdon County, Pennsylvania, upon drying on the water bath for one hour, lost in weight ·76, and after being kept in the oven at 545° Fah., the loss was reduced to ·35; upon then being tested in a bulb tube over a Bunsen burner, water was detected. The total amount of water found in this sample was 2·02, or 1·26 more than the loss at the temperature of the bath.

A sample of gas-coal from West Virginia gave very nearly similar results. Another sample of the kind of coal from the Kanawha River, upon exposure in the oven for one hour, at about 560° Fah., was found not to have lost, but to have gained nearly 1 per cent. over its normal weight, and then when tested in the bulb tube over a Bunsen burner gave off a very appreciable amount of water.

Quite a number of analyses were made of the true brown coals, or lignites of Southern Arkansas, to ascertain their value for the production of paraffin, and it was found that they did not part with all their water, which amounted to an average of about 19 per cent., until destructive distillation commenced. A portion of

[1] A paper read before the American Institute of Mining Engineers, at the Philadelphia meeting, June 26th, 1876.

a sample of coal from east of the Rocky Mountains, on the line of the Union Pacific Railroad, was placed in the hot-air oven, and for an hour and a half kept at a temperature of 170° Fah., when it was found to have lost in weight 5·72; kept for one hour more at a temperature of 280° Fah., the loss was increased to 7·31, and again for two hours more at the same temperature, the whole loss was found to be 7·55. Another portion of the same sample was then subjected for three hours to a temperature of 500° Fah., when the loss was further increased to 9·55. The watery vapour from this last portion was condensed in a cold glass tube, the tube was carefully weighed, and then the water cautiously evaporated, afterwards the tube was weighed again, and, from the loss, the weight of water was ascertained. The coal was then weighed, and its loss was found to correspond very nearly with the weight of the water. Upon immediately testing it in a bulb tube over a Bunsen burner more water passed off, and upon continuing it over the burner at a high temperature, white fumes and a dark brown oil passed off, but no more water. The actual amount of water in this sample was subsequently found to be 12·50.

I have made many other experiments, the results of which I need not give in detail; collectively they have tended to prove, (1) that water exists in the several classes of coal in two conditions—*i.e.* combined and uncombined, but in these conditions not constant in relative proportions. (2) That some coals will and some will not, irrespective of the class to which they belong, when finely pulverized and left open to the air, gain in weight by taking oxygen, while at the same time they lose in weight by losing water and hydrocarbons, at temperatures varying between that of boiling water, and one that is sufficient for destructive distillation. (3) That all coals, when deprived by heat of any portion of their normal water, will, upon exposure to the open air at common temperatures, immediately begin to regain their loss. It, therefore, follows that correct weighing cannot be done with the material uninclosed. (4) That the method of determining the water by merely finding the loss which the coal sustains by drying for one hour at 212° Fah., or for any length of time, or at any temperature, whether over sulphuric acid or not, gives fallacious results.

AN AUTOMATIC SIGNAL BUOY.

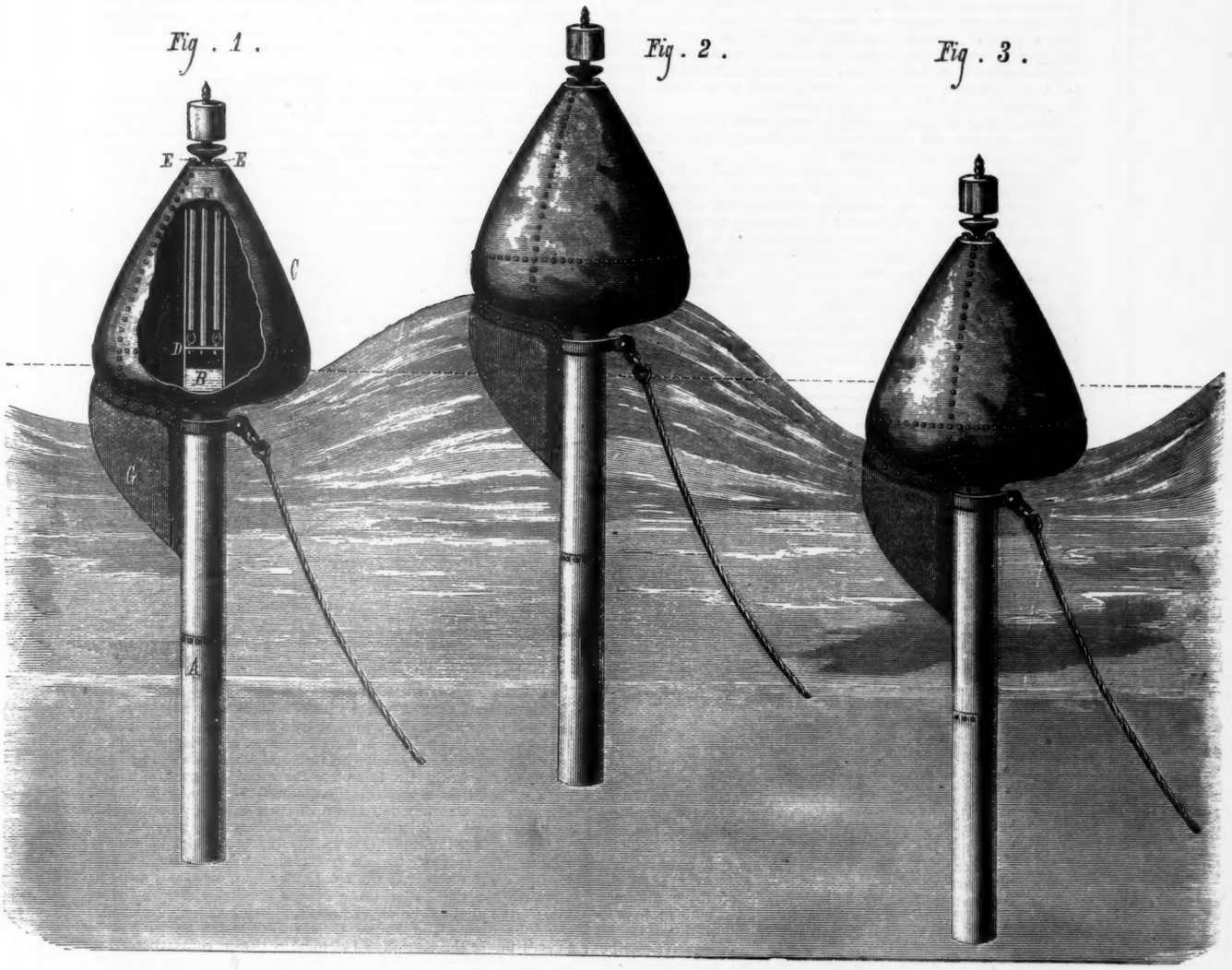
THE ocean is confessedly the great highway of commerce, and, unlike routes by land, the conditions of travel are not subject to human control. Therefore, after seeing that his ships are staunch and well found, all that man can do is to furnish efficient guides in the shape of charts and signals. With the history of these, from the ancient Pharos or lighthouse, and the self-acting bells of the monks on the rocky coast of Great Britain, down to the Fresnel lantern and electric light on the one hand, and the steam fog-horn on the other, our readers are no doubt sufficiently familiar. The amount of labour and ingenuity that has been expended in this direction is something wonderful, the efforts of our ablest scientific men, such as Faraday, Fresnel, Tyndall, Henry, and others, having been devoted to it for years. Nor is this so much to be wondered at, when we consider the importance of the interests that depend upon the efficiency of such appliances. To have prevented the fearful disaster of the "Schiller" or the "Atlantic" would have well repaid the life-long labours of our ablest scientists. At the same time we must remember that the value of lighthouses or signal buoys may be shown in other ways than by the prevention of absolute disaster. A proper system of lights and other signals enables the mariner to shorten his voyage by a large percentage, and thus to facilitate travel, cheapen freights, and by so much add to the comforts of life. It would make a great difference to a large vessel whether she should be obliged to lay off and wait for fog to dispel, or whether she could steer boldly into port in any weather.

Our readers are no doubt familiar with the fact that there are two agencies by which signals may be transmitted at sea—light and sound. The first is, beyond all question, the most efficient and precise when the atmospheric conditions are favourable; but it unfortunately happens that the strongest lights are liable to be obscured at the very time when most needed. It takes but a very moderate amount of fog or mist to obscure the most powerful light. Even the most powerful electric lights have failed to project a beam half way across the river at New York, so as to enable the ferry-boats to move about intelligently; but this is not very surprising to those who have seen the light produced by fifty powerful voltaic cells completely cut off by the vapour of a few teaspoonsful of water. During heavy fogs, therefore, either by night or day, recourse is had to sound produced by the ringing of bells, the firing of guns, the blowing of fog-horns, whistles, sirens, &c., and these have been found of great value, though, as ordinarily employed, they have several obvious and important defects, the most important of which is that, being always placed on land, or moored on comparatively ponderous structures, it is dangerous for any vessel to approach them too closely. Let us take, for example, a fog-horn placed on a rocky promontory, and requiring a steam boiler, with fuel and attendants, to operate it. From such a signal all vessels that have a regard for their own safety must keep as far away as possible. To approach the signal, whether for the purpose of making accurate observations, or for any other reason, is to rush into a position of danger. If, however, these signals could only be placed alongside the ordinary track of the vessel, telling the mariner that he is right and in a position of safety, and not as other signals, lights, or sounds, that he is wrong and in a position of danger, the advantage would be enormous. And if, in addition to this, vessels might safely approach these stations, observe their numbers, and take a new departure from each, the navigation of the most difficult and dangerous channel, during even the darkest hours or the most foggy weather, would be rendered easy and safe.

But to accomplish this it is evident that the signals must be automatic. There is no opportunity for the employment of steam or the labour of men, the motion of the water itself being the only agent that can be depended on for operating the apparatus. Acting upon this idea, several inventors have attempted to devise an arrangement which would operate of itself, and amongst the earliest records of the Patent Office we find descriptions of such efforts. In every case, however, the power sought to be utilized has been the force of the waves, and consequently in calm weather (which is often as dangerous as any, owing to fogs) the signal fails. Indeed, so hopeless seemed the prospect of producing a device which would operate in a calm, that several of our most prominent scientific men boldly declared that the thing was an impossibility. But unless a project seeks to absolutely violate some well-known law of nature, it is never safe to declare that it cannot be carried out. This has been shown on many previous occasions, and the automatic signal buoy which we are about to describe furnishes another illustration of this great truth.

The signal buoy which we illustrate, and which is the invention of Mr. J. M. Courtenay, of Idlewild, near Cornwall-on-the-Hudson, N.Y., consists, as will be seen, of a large can or shell, to which a tube, 32 or more feet in length, is attached. This tube passes through the buoy, as shown in fig. 1, and is furnished with a diaphragm, D, through which pass the two tubes, E, E, and the tube, F. The tube, F, is open at both ends, the upper end being so placed that any air passing through it will act upon the whistle placed upon the top of the buoy. The tubes, E and E, are open at the top, and at the bottom are fitted with ball valves, which allow air to pass *down*, but prevent it from passing up. If, now, we were to suppose the buoy to remain stationary, and the level of the water to rise and fall around it, the following would be its action, which is very simple. As the water fell and descended in the tube, B, air would rush in through the tubes, E, E, and F, the valves in E, E being arranged to allow this. As the water rose again, the air between the diaphragm, D, and the water level would be compressed, and as the valves in E, E would close, the only exit would be the tube, F, in issuing from which the air would act on the whistle. It will thus be seen that the action of the apparatus itself is of the simplest character. There is not the slightest possibility of its getting out of order or failing to do its duty.

The next point, however, viz., the mode in which the ordinary motion of the water produces the desired result, demands close attention. Careful observation and measurement have shown that in the case of ordinary waves the trough or depression extends as far below the mean level as the crest of the wave extends above it, and at a depth a little greater than the extreme height of the wave the body of water is actually undisturbed. If, therefore, a tube should be let down into the water, so that its lower end should reach a depth below the point to which the waves oscillate, the surface of the water in this tube would remain constant, and would represent the mean level of the ocean or river. This is the case with the tube, A, shown in fig. 1. Unless disturbed by other causes, the level, B, remains always the same. The buoy, however, floats on the surface of the waves like a boat or a chip, and *it* is therefore caused to rise and fall, carrying the tube, A, with it. The water in the tube acts, therefore, like a stationary piston surrounded with a movable cylinder. With every passing undulation the buoy



MR. J. M. COURTENAY'S AUTOMATIC SIGNAL BUOY.

will be first raised, drawing air into the tube, A, and then lowered so as to expel this air.

The varying position of the buoy, and its relation to the waves, are shown in figs. 2 and 3.

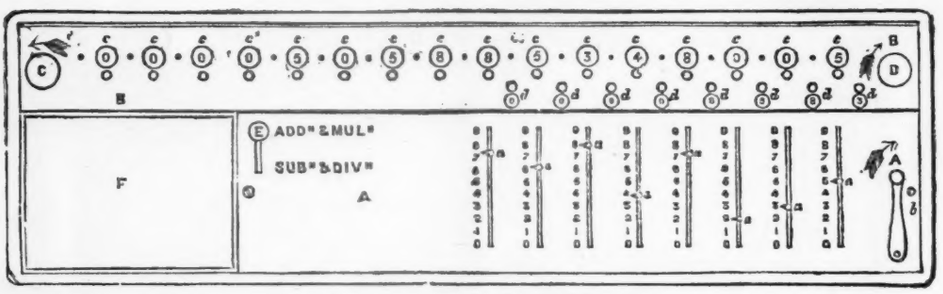
It will thus be seen that when approached in a proper manner, and freed from unnecessary complications, the mode of action of this signal buoy is easily understood.

It is evident that the pressure to which the air above the diaphragm, D, is subjected does not depend at all upon the height or violence of the waves, but upon the weight of the buoy and its relation to the diameter of the tube, A, while the limit to the amount of pressure per square inch that may be obtained depends upon the length of the tube, A. The *quantity* of air that is inspired at each movement depends upon the height to which the buoy is raised, and it is found that an oscillation of twelve inches is amply sufficient to operate the whistle effectively, so that a mere ordinary ground swell, or the small waves in a river are all that is absolutely required.

These buoys may be moored in any depth of water. Each buoy is provided with a sort of wing or rudder, G, which causes it to maintain a proper position.

The signal buoy which we have thus described is no longer a mere experimental affair, but a tried and practical success. One has been placed at the mouth of Gedney's Channel, of which the dimensions are as follows: Diameter at float line, 12 ft.; height above float line, 13½ ft.; length of tube, A, 32 ft.; size of whistle, 10 in. diameter by 18 in. long. With the ordinary ground swell this buoy has been heard at a distance of seven to nine miles, and under some conditions of the atmosphere could undoubtedly be heard much further. We have conversed with several gentlemen who have witnessed its operation, and there cannot possibly be a doubt of its being a complete practical success. The inventor has some nine others under way, and we trust that the time is not far distant when entire coasts will be dotted with them. If properly numbered they would enable any vessel, even in the densest fog, to ascertain her position with precision. And, even without approaching them, it would be easy for a vessel to determine her location, provided the whistles were of different tones. The inventor has already, by means of different-sized whistles, produced nine distinct sounds, and thus each buoy may be made to have a different voice, enabling those who become accustomed to it to identify it in a fog by its sound alone. But it is proposed to go farther than that, and, by an ingenious arrangement of valves, to cause the sounds to intermit, and so identify the buoy to strangers, as lighthouses are identified by being stationary, or revolving, or flash. Thus one buoy may moan continuously with each wave, another emit short blasts—one, two, or three, as may be arranged.

In estimating the powers of these whistles, it is necessary to bear in mind a remarkable fact which has been developed by the experiments connected with these buoys, but which strictly accords with the accepted theory of the subject. It is that the power of a whistle operated by compressed air is much greater than that of the same whistle subjected to steam of equal pressure. The reason of this is obvious. In the case of the air the medium in which the sound is originated and propagated is homogeneous, while in the case of steam there is an important loss, owing to the transfer of the vibrations from a rare to a dense medium. It is not surprising, therefore, that these whistles should be heard at great distances, and we have the positive assurance of a gentleman, in no way connected with the invention, that he heard one distinctly at a distance of 10½ miles. We regard them as the most important invention in this direction that has been made during the last half-century, and we hope ere long to see them adopted by every maritime nation.



M. THOMAS DE COLMAR'S ARITHMOMETER.

THE ARITHMOMETER.

REFERRING to Dr. Ball's recent lecture on Calculating Machines at the Loan Exhibition of Scientific Instruments at Kensington, a short description of M. Thomas de Colmar's Arithmometer, which he then referred to, and which is, in fact, the only calculating machine now in use, may be of interest to some of our readers.

The instruments are, we believe, made of three different sizes, giving products of 20 figures, 16 figures, and 12 figures respectively; but they differ only in length, the width and depth being the same in each case. The one we are about to describe is only 22 in. long, 6¼ in. wide, and 3½ in. deep, and gives a product of 16 figures. We can best give an idea of the great saving of time effected by this instrument when we state that with it eight figures (tens of millions) can be multiplied by eight figures in 18 seconds, 16 figures be divided by eight figures in 20 seconds, and a square root of 16 figures be extracted, with the proof, in less than two minutes.

Our illustration shows a top view of an arithmometer, the lid of the box being removed. It is constructed chiefly of a brass plate, A, furnished with eight slots, as shown. Directly under these slots are mounted eight drums, each having nine elongated cog teeth of successively decreasing length. Over each drum, and between it and the slot, is mounted a square shaft, on which slides a pinion wheel so as to catch any number of teeth on the drum. Each of these pinion wheels is moved by a button, *a*, of which there is one in each slot, the figures at the sides of the slots showing the proper position of each button, *a*, for any work to be performed by the instrument.

The cogged drums gear by bevel wheels with a long horizontal shaft, which is also in gear with the vertical shaft moved by the handle *b*, by which the instrument is worked. B is a movable brass plate which can turn and slide on a round bar-hinge at the back. In this plate there are 16 holes, *c*, under each of which is a movable disc numbered from 0 to 9, and arranged so that any one figure of each disc may be brought under its corresponding hole, *c*. These discs have bevel wheels which gear with bevel wheels on the before-mentioned square shafts. The movable plate B is also furnished with the holes *d*, having discs numbered from 0 to 9 underneath, and are for showing the number of turns of the handle, giving by this means the quotient in division, and showing the multiplier in multiplication. The knobs C and D are for bringing the figures under the holes *c* and *d*, to zero before commencing an operation, and the knob E is for setting the instrument to work addition and multiplication, or subtraction and division. F is a small slate for memoranda.

Before further describing the working of the machine, we would remark that if the knob E be placed at addition, each turn of the handle will carry the figures marked by the buttons, *a*, under the indicator-holes, *c*, or add them to the figures already under the holes, *c*; while if the knob be placed at subtraction each turn of the handle will subtract from the figures under the holes, *c*, the numbers marked by the buttons, *a*.

Such being the general construction and principle of the machine, we will now proceed to give an example of its operation for multiplication, the operations for addition and subtraction being sufficiently explained in the preceding paragraph.

Thus, to multiply 76,847,235
by 6,583,

mark the multiplicand on the plate, A, by the buttons, *a*, as

shown in the illustration; set the knob, E, at addition and multiplication, then turn the handle, *b*, three times for the unit figure of the multiplier, and three times the multiplicand—viz., 230,541,705—will appear under the holes, *c*, in the movable plate, B. This plate must now be raised and moved one figure or station to the right, and the handle turned eight times for the second figure of the multiplier, and 6,378,320,505 will appear under the holes, *c*. Move the plate, B, again to the right, and turn the handle five times for the third figure of the multiplier, and 44,801,938,005 will be brought under the holes, *c*. And finally, by moving the plate, B, once more to the right, and turning the handle six times for the last figure of the multiplier, the total product, 505,885,348,005, will appear under the holes *c*, and the figures of the multiplier—viz., 6,583—will appear under the holes, *d*.

In division the operation is as simple as for multiplication, and is performed as follows, thus: to divide 414,591,904 by 4,768, set up the dividend on the plate B and the divisor on the plate A, commencing with the unit figure in each case to the right hand; place the knob E at subtraction and division, and move the plate B to the right until the second figure (from the left) of the dividend is over the first figure (4) of the divisor; turn the handle eight times and 8 will appear in the quotient holes *d*, and will give the first figure of the quotient, while the dividend will now show 33,151,904, having been reduced by eight times the divisor, as in ordinary arithmetic; move the plate B one place to the left, and turn the handle six times for the second figure of the quotient, and the dividend will be further reduced by six times the divisor, and will mark 4,543,904; again move the plate and turn the handle nine times, and after moving the plate B and turning the handle five times and three times respectively, the holes *c* will all show noughts and the quotient holes *d* will show 86,953, which is the quotient required; if there had been any remainder it would have appeared in the holes *c*.

Although by the ordinary limits of the machine a product of sixteen places of figures and a quotient of nine places of figures only can be obtained, yet by an intermediate record by the operator these limits may be virtually doubled for multiplication; while for division, provided the divisor does not exceed eight places of figures, the dividend and the quotient may be unlimited.

The use of the arithmometer in actuarial and other calculations has been shown in the papers read by Major-General Hannyngton and Mr. Peter Gray, F.R.A.S., F.R.M.S., respectively, at the Institute of Actuaries (see the "Journal of the Institute of Actuaries," p. 224, vol. xvi., and p. 249, vol. xvii.); and Mr. Thomas T. P. Bruce Warren, in a paper read before the Society of Telegraph Engineers, has shown the application of the instrument to electrical computations.

The arithmometer is now used in many Government offices, in nearly all the life insurance offices in England, and in several observatories, of which we may mention the Cambridge Observatory (Professor Adams) and the Dun Echt Observatory (Lord Lindsay's). Sir H. Thompson, Professor Tait, Professor Galbraith, and Dr. Ball also use them in the universities and colleges with which they are respectively connected. Mr. G. F. Redfern, of 4, South Street, Finsbury, is sole agent for the arithmometer.

THE PATENT OFFICE.

THE Report of the Commissioners of Patents for 1875 has been recently issued. Beyond giving a statement of the actual business done, by a record of the number of applications, of patents passed, &c., and a tabular account of the same from 1852 to 1875, this Report contains little of current interest; the recital of the above facts occupying the first page, the remaining sixteen pages being filled up with retrospective matter, most of which is to be found in the catalogues of the publications of the Great Seal Patent Office.

It appears that the number of new applications for patents within the year 1875 was 4,561, the corresponding number for 1874 being 4,492; the number of these applications resulting in the passing of patents for 1875 was 3,112 against 3,162 in 1874. The number of final specifications filed in pursuance of the granting of patents was 2,887 in 1875. The number of complete specifications upon which patents were sealed was 162; the number void from neglect to file final specifications being 63, against 58 void from the same reason in 1874. No mention is made of the recent reorganization of the staff of the office, and the resignation of Mr. B. Woodcroft, the Clerk to the Commissioners, under whose active supervision the Patent Office has arrived at its present stage of usefulness to inventors and practical men. The existence of a free library and reading-rooms is mentioned, but the great facilities offered thereby to all interested in science are not enlarged upon, although it is believed that the great opportunities that are so easily within the reach of all concerned to consult the standard text-books, periodicals, &c., of writers in all languages in the various departments of science and art, are by no means so largely employed as the vast amount of inventive genius displayed in the number of applications for patents would seem to require. It should be generally known that this highly important library is open free every day from 10 to 4, the only formality necessary to be gone through being the registration of the name and address of the reader; and that the ticket system of the British Museum is not in force, the greater number of the books being on open shelves, accessible to all.

A large part of the Report is taken up in the recital of the Report of the Commissioners to the Lords of the Treasury in 1858, urging the necessity of providing more suitable accommodation for the Patent Office, Library, and Museum, the Treasury duly recommending the Report to the consideration of Parliament in 1858, 1862, and every successive year from 1865 to 1874; but it appears that beyond the provision of additional rooms for the library on the second floor of the present building, no action has been taken on the matter. In 1862 the Treasury recommended that a site be appropriated on the Thames Embankment, and a plan which accompanies the present Report demonstrates the great advantage which would be gained by removing the office and its accessories to so central a site.

At the recent meeting of the British Association, Sir William Thomson, in the inaugural address to the section of which he was president, alluded to a visit to the Patent Office at Washington as follows:—

"The Patent Museum of Washington, an institution of which the nation is justly proud, and the beneficent working of the United States patent laws, deserve notice in the section of the British Association concerned with branches of science to which nine-tenths of all the useful patents of the world owe their foundations. I was much struck with the prevalence of patented inventions in the Exhibition: it seemed to me that every good thing deserving a patent was patented. I asked one inventor of a very good invention, 'Why don't you patent it in England?' He answered, 'The conditions in England are too onerous.' We certainly are far behind America's wisdom in this respect. If Europe does not amend its patent laws (England in the opposite direction to that proposed in the Bills before the last two sessions of Parliament), America will speedily become the nursery of useful inventions for the world."

On this question of amendment of our patent laws, a paper was read at the same meeting by Mr. St. John Vincent Day, "On Recent Attempts at Patent Legislation." He confined his attention to the Bill of 1876, which he described as in many respects an improvement upon its immediate predecessor of 1875. In so far as the Bill provided for the examination of applications for patents, it might be welcomed as a proposal for the introduction into the English patent law of a system which had been found on the whole to work well in the United States. How many examiners might be necessary to discharge the serious responsibilities which this office would entail it was impossible to estimate; but there could not be a doubt in the mind of any one who knew how much time (sometimes weeks together) was consumed in making an exhaustive examination into the novelty of a supposed invention, that some dozens of examiners would be necessary. He looked upon the system of provisional protection under a provisional specification as one of the greatest boons which the law had ever conferred upon inventors, and he deplored the attempt to deprive them of it as proposed in the Bill of 1876. He would still maintain the system of filing a provisional specification, and he would grant protection therein as at present. After remarking upon other points in the Bill, he concluded by expressing his opinion that if, through apathy, indifference, or want of energy, inventors allowed such a Bill as that just now abandoned to slip through Parliament in a subsequent session, they would have cause to bitterly reproach themselves.

In the discussion which followed the reading of this paper, Mr. Trevelyan said he would abolish the Patent Laws altogether, and give the inventor protection on the payment of £5 for registration of his invention. Mr. Macknight thought that the sums exacted from inventors should not be more than was sufficient to repay the Government for the expenses of the office. Dr. Ryalls expressed his opinion that examiners could not discharge the duties of judges efficiently or fairly in the absence of the persons interested. Mr. F. J. Bramwell said that the Lord Chancellor himself, in bringing forward his Bill, had assured the House that he was not a strenuous advocate of Patent Law.

It appeared in the highest degree undesirable that a Bill should be brought forward for the amendment of a law by an officer of the Crown who, at the very time of bringing it forward, expressed his indifference to the existence of any such law at all; and it was not to be wondered at if the Bill, produced under such auspices, was, in the opinion of those who are earnestly desiring the maintenance of a Patent Law, a Bill calculated to defeat rather than promote that object. Not only was it the opinion of those who were in favour of a Patent Law that the Lord Chancellor's Bill of last session, and still more the Chancellor's Bill of the previous session, was calculated to destroy patents, but that was the opinion likewise of those who were avowed opponents of Patent Law. In the 1875 Bill of the Lord Chancellor, there was a provision which showed conclusively that the framer of the Bill had either framed it without employing due consideration, or, if he had employed due consideration, had, as a result of that employment, come to one of the most extraordinary conclusions ever arrived at in a Bill treating of patents for inventions. That was the clause which directs the examiners to consider and report whether the invention in respect of which protection was sought was one entirely new, or whether it was made up wholly or in part of known arrangements or contrivances; and if it appeared that the invention was made up in part of old arrangements or contrivances, then a shorter term was granted for the existence of the patent. Now, every invention, no matter how important or how novel, is made up of old things, and it appears as unreasonable to refuse a patent to an inventor of a new and useful combination of old things, or to reduce the period of protection afforded by that patent, as it would be to refuse a copyright because the work proposed to be protected by that right was made up of the old letters of the alphabet. This particular clause was expunged from the Bill of 1876; but it showed the mind of the framer of the Bill of 1875, and also the framer of the Bill of 1876—the Lord Chancellor. If further legislation was to be attempted in respect to patents, it ought to be taken out of the hands of the lawyers. As a rule, the lawyer is not acquainted with manufacturing processes. It seems to be thought that lawyers have a special claim to dominate in patent legislation, perhaps on account of the great gravity of the litigation which arises out of patents. This notion of excessive litigation in reference to patent matters is absolutely unfounded. An eminent barrister connected with patent litigation, when it does arise, had assured Mr. Bramwell that on an average of many years only nine patent actions or suits go to the stage of a primary decision in each year, and an examination of files of *The Times* for the year ending November, 1874, showed the accuracy of the statement which had been made. Within the last ten years there have sat a Royal Commission and a Parliamentary Committee of Inquiry upon Patent Law. That Commission and that Committee, after taking evidence from competent persons, evidence of persons of varying views, reported; and it did seem the duty of an officer of the Crown who brings forward a Bill to improve patent legislation to frame that Bill upon the basis of such reports, and not upon his mere inner consciousness, disregarding the labours and advice of others, who certainly are, in the judgment of inventors and manufacturers, more competent to deal with the subject than a lawyer, however eminent that lawyer may be. Mr. Bramwell then proceeded to the question of the examinations into novelty and frivolity. He had long had very great doubts whether it is desirable to make an examination even into novelty; but if such an examination be made, the very first care must be to appoint a sufficient number of men of scientific attainments or of good experience. This is a difficult task in itself; even when the greatest care has been taken it is certain that some mistakes will be made, and some hardships will be suffered, and we have to consider whether the advantages to be attained are sufficient to justify the risk. After all, what is the benefit to be derived from an examination into the novelty of an invention? Sometimes it is said, it is to protect the inventor. The answer to that is, if you make the inventors into classes separate from the community at large, the inventor says, "For Heaven's sake leave us alone; we do not need to be protected against ourselves." But others put the desirability of the examination into novelty on broader grounds. They say it is undesirable a patent should be granted for a thing which is not new, because the public may thereby be prohibited from using something which the patentee claims as his invention. The answer to this is, a patent granted for a thing which is not new is, if not void, voidable, and then in truth a very small amount of harm results. Mr. Bramwell then went on to illustrate his meaning by reference to the inventions of James Watt, Dr. Potts (the inventor of the method of driving piles by exhaustion of the air), and Dr. Siemens, all of whom he urged would, probably, have been refused a patent by the examining body. It appeared certain that we should not have an examination as to frivolity; and if we were to have examination as to novelty, that examination should be fenced with precautions to prevent an inventor being injured by a wrongful decision. It was recommended by the Committee of the Society for the Amendment of the Law that a patentee should have, notwithstanding the adverse report of the examiner, a right to demand his patent if he still so pleased, but that the specification should have appended to it the decision of the examiner, and that any person bringing an action under such a patent should be compelled to give security for the costs; and that in the event of his failing, and failing on the grounds put forward by the report of the examiner, he should pay the whole costs of his opponent as between solicitor and client, and not the mere taxed costs. Some protection such as this against the mistake of novelty examiners was absolutely necessary. There were two other provisions in last year's Bill which were absolutely and obviously unnecessary in one and the same Bill. The one provision was that a patentee should be compelled to give licences to others; the other that if he did not put his invention to work within two years he should lose his patent. With respect to the obligatory granting of licences, in the various discussions which there have been from time to time, he had reluctantly acceded to this, because he thought it would do away with the last objection of the objectors; but there must be precautions adopted here, and very serious precautions. Unless great care is taken the very object of the provision may be frustrated. Imagine the case of a person who had made an invention by which he is enabled to utilize that which had been previously a waste product; that waste product may be very small in quantity, it may only be commercially possible to utilize it as long as its price remains low. Its price would remain comparatively low if the only customer were the one patentee; but if he were compelled to licence his competitors, the price would rise, and the very industry come to an end. But in a Patent Bill containing a provision for obligatory licences it manifestly is not needed that there should be a deprivation of the patent if the invention be not put to work at all; because, when a patentee is bound to grant licences he cannot vexatiously employ a patent for purposes of obstruction; and, on the other hand, such is the very natural objection of manufacturers to adopt new processes which may render existing machinery valueless, that a patentee is not, as is ordinarily supposed, besieged by manufacturers eager to put his invention into practice; but he has to seek after the manufacturers, and then entreat that his invention may be practically worked, and the more important and widespread would be the result of the practice of the invention the greater is his difficulty in getting it into use. Take, for instance, an invention applicable to blast furnaces—a furnace costing, say, £20,000. Blast furnaces are easily put out of order by any error in management, and it is extremely difficult for the inventor of an improvement in such furnace, or in the operations connected therewith, to obtain permission, even at his own expense, to make a trial. Similarly imagine a substantive invention in connection with ocean steamers. The proprietor of one of these steamers naturally hesitates before he will allow an experiment to be made; as, in addition to the danger to the ship, worth perhaps £100,000, failure may imperil the lives of the crew and passengers, and may involve the proprietor who had given his sanction to the experiment in loss of reputation and in ruin. It is on grounds such as these that he urged the unfairness of deprivation of a patent if not put to work within two years, even if there were not the obligatory licence clause; but with such a clause, it is manifest there is no need whatever for the revocation clause for non-working, and no such clause would be suggested if the true object of the Bill were to encourage invention and to stimulate industry.

Further, in reference to this same subject we have to record a meeting of the United States Patent Association on September 7, 1876, at the Franklin Institute, Philadelphia, Pa., for the purpose of suggesting means for the improvement of the patent system and the formation of an international association for promoting uniformity of patent laws in all countries. Among the members present were the Hon. J. M. Thacher, ex-United States Patent Commissioner; Professor Hedrick, of the United States Patent Office; W. C. Dodge, of Washington, and John S. Perry, of Albany, N.Y., President of the Association.

President Perry called the meeting to order, and read an address, in which he took as subjects of consideration: First, the importance of the patent system in general; and, second, that of the United States in particular, viewed both in respect to the development of original invention and as inciting inventors to persevere in the perfecting of their plans. He showed the benefits which have arisen from the patent system by a review of the condition of Europe before the patent law was recognized. So long as the laws of property were neither recognized nor properly defined, there could be little incentive to invention or the pushing forward of appliances for the better comfort of mankind. Often an individual, like Roger Bacon, would be on the

eve of an invention, and often, for that matter, did invent; but, well knowing that his rights would be unrecognized, he failed to make it public. Indeed, it is well known that several inventions and discoveries of great value, which have since been re-invented, were really made, but suffered to die with the inventor or discoverer from this cause. The first trace of patent law is, he thought, to be found in the reigns of Henry III. and Edward IV. of England, in the thirteenth and fifteenth centuries, about which periods the services of the villeins or serfs gradually become less onerous and uncertain.

He furthermore said: "Patents are sometimes characterized as monopolies, and even as vicious monopolies. With equal reason might the possession of wealth honestly acquired be denounced as a trespass upon the rights of others. To take money unlawfully is called stealing; to appropriate an invention is not by some considered very dishonourable. The public seem to have lost sight of the fact that the inventor has taken nothing which it had before; that he has from his own brain brought into existence and perfected, at his own cost of labour and money, a production as new to the world, and perhaps as useful, as the gold which the miner brings forth from the hidden recesses of the mountains. The most bitter opposition the patent system meets with is from the agriculturists, and they of all men are the most benefited by its provisions. With the high cost for labour that has existed during the past twelve years, the business of farming could not have been carried on without the improved machinery that inventors and progressive manufacturers have provided. The importance of the patent system in general is shown in that a vast number of articles have been through its instrumentality added to the means of human happiness, of which the latter must otherwise from necessity have been deprived." In reference to the importance of the patent system in the United States, the speaker argued that "the history of patent protection is almost coincident with our existence as an independent nation. The law of patents, as it now stands in the United States, rests on the statutes of February 21, 1783, and April 7, 1800. These statutes have been modified several times, yet our patent law as it now stands is far from being perfect, and it is in the hope of aiding in correcting its errors, and in giving it a wider scope, that the United States Association has been formed."

Whereupon the "Scientific American" remarks:—"These views are in the main sound, although tinged with a few misconceptions. Patents, the chairman assumes, are not monopolies, but inherent rights. The poor miner, who controls the gold that his industry brings from the rocks, is just as much of a monopolist, he tells us, as the wealthy patentee, who compels every poor woman to pay him forty dollars royalty, for the privilege of earning her living by means of his patent sewing machine. Such reasoning, Mr. Chairman, will not do. The people know better. They know by actual daily experience that patents are monopolies, some of them of the most oppressive kind; and no sugar-coating by any Patent Association will alter the fact. It is because patents *are* monopolies of the vicious kind that they are valuable, and in such great demand. Of what account would a patent be, if the patentee were not clothed with authority over his fellow creatures to enforce his private demands, in respect to his patent? Of none whatever.

"According to President Perry, the miner who first discovered gold in the Rocky Mountains was the natural patentee of the entire range, as respects the precious metal. He takes nothing that the public had before; on the other hand, by his discovery, he contributes to the general supply of gold. Therefore, no one but the discoverer, or the favoured few whom he permits, ought to be allowed to work at gold mining on the premises. This is poor logic for the United States Patent Association to promulgate.

"Patents, as we have stated, are pure monopolies. They are only tolerated and granted for reasons of public policy. They are issued solely as rewards: for the mere purpose of stimulating people to discover, invent, and study out new forms of industry. The general weal is promoted by increasing the number and variety of industrial arts, which all the people may freely and equally enjoy. Instead of rewarding the inventor by paying him a sum in cash from the collected taxes in the treasury, the Government gives him a patent, or, in other words, makes him his own tax gatherer; and authorizes him to compel the people, by force if necessary, to satisfy his demands.

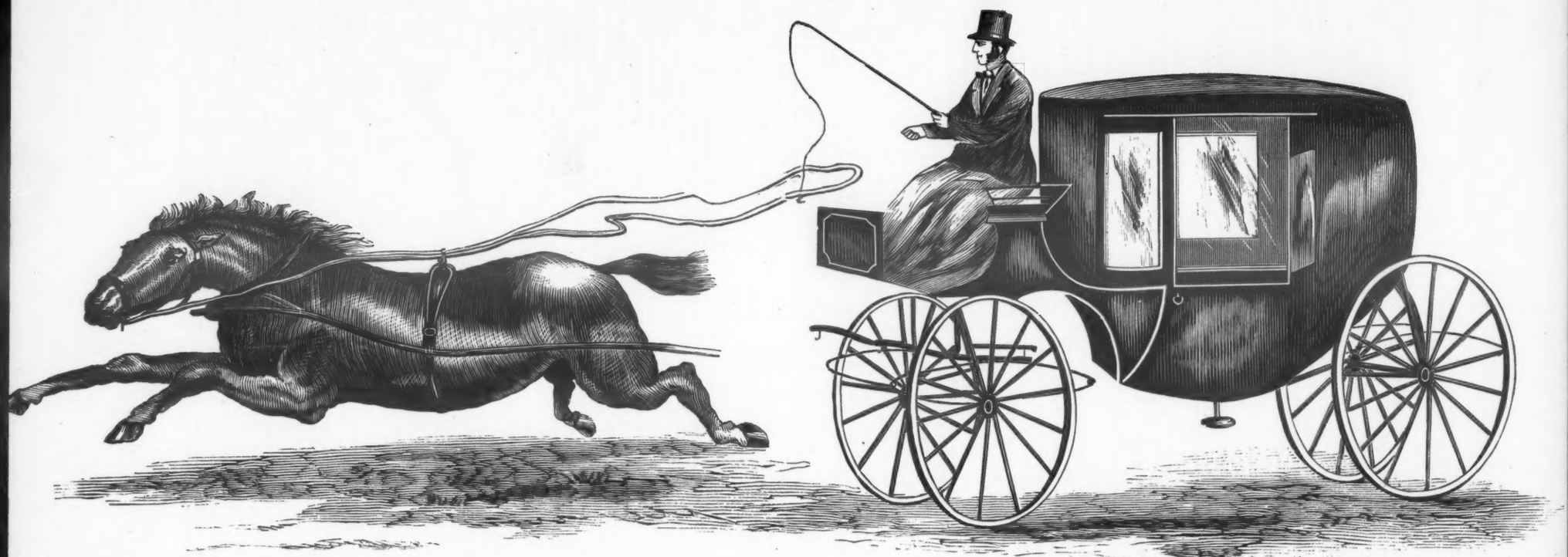
"The redeeming feature of our patent monopoly system is that it effects its object, it brings out new improvements, and is limited to a brief period. Our patents run for seventeen years—a short time in the life of a nation; the inventions then become public property, and everybody may enjoy them, free from the annoying whip and spur of any wealthy private corporation or patent holder. Great as are the inconveniences of our patent system, the benefits are amazing, and greatly exceed the drawbacks. So long as this continues to be the case, the patent laws will stand.

THE PREVENTION OF ACCIDENTS CAUSED BY RUNAWAY HORSES.

MANY methods have been introduced with the object of preventing the often-recurring sad accidents to which the occupants of vehicles are at all times exposed through the horses taking fright or running away. Scarcely a week passes by without some sad occurrence of this kind being recorded in the newspapers; and the time, therefore, appears to us all the more opportune to offer a few remarks on some of the various means which have been suggested for the prevention of these accidents.

The necessity of taking all precautionary measures against the running away of horses cannot be too strongly recommended to all owners of carriage horses, but more especially in cases where young, fiery steeds are used. It is well known that these runaway accidents often occur from the slightest causes: the least unusual or unexpected sights are, in many cases, the immediate precursors of lamentable accidents, carrying death and destruction where ease, comfort, and enjoyment were anticipated. A piece of paper suddenly carried by the wind in front of a horse, a dog crossing the carriage path, a loose harness-strap, lightning, or thunder, may so frighten a horse as to cause him to run away; and it then becomes a matter of earnest congratulation if the runaway horse can be stopped before damaging the carriage or injuring the occupants, or causing some other serious damage through a road-collison. It is, perhaps, needless to remark that the passers-by are, as a rule, altogether unable to prevent fatal results from happening. Many other reasons will doubtless suggest themselves to our readers, increasing the likelihood of fresh horses running away; and it is certainly a matter of surprise that, notwithstanding good preventative means have been devised with a view of preventing these fatalities, so little has been done to bring them into general use. Thus, Hartmann, of Millersville, has introduced a sort of bit for the horse's mouth, which is so under the control of the coachman that, in the event of the horse attempting to run away, the coachman, by pulling at an inner rein connecting the bit, may bring the latter close up to the horse's larynx, and so stop his freak. This method of *reining-in* may prove effective with docile animals; but with others of a more fiery disposition it is thought that with time they would become accustomed to it, and so no longer heed it. Another method which has been suggested consists in giving the coachman a greater hold on the horse's head, by a combination of leverages and independent reins, so that, in case the horse should take fright, the coachman is able to turn the horse's head completely on one side, so depriving him of his sight in the direction he is actually running; when two or more horses are so harnessed to one carriage, their pulling in various directions neutralizes the draught effect. A third method which has been propounded, which appears less applicable to actual practice than it does to theory, consists in applying an electric shock to the horse's bit simultaneously with his attempt to run away. The question presents itself, however, whether this method, which in its mild application would certainly not act detrimentally on the horse's legs, would not really increase the horse's fright, unless, indeed, a complete battery was attached to the carriage, which in its effect would throw the horse to the ground, or kill him there and then. A fourth plan we have seen suggested consists in blinding the horse by a kind of hood falling over his eyes at the time required, so preventing him from seeing anything, and bringing him to a compulsory standstill.

In 1874, Gustav Bosinger, of Ravensburg, in Würtemberg, suggested another method, for which he obtained a patent. By means of his invention, which it is said can be fitted up to any carriage by an ordinary blacksmith, and is completely hidden from view, the coachman is enabled to disconnect the horse entirely from the carriage at any desired moment by a lever-handle, which simultaneously applies a brake to the carriage hind-wheels, so bringing the latter to a dead standstill on the horse being released from the carriage. This plan has shown itself thoroughly efficient in practice; but the fact that the application of Bosinger's apparatus is costly may prevent its general use. Mr. Hill, whose patented runaway horse apparatus we herewith illustrate, is apparently following—though, no doubt, unconsciously—Mr. Bosinger's plan; but if costliness is a great drawback to the adoption of the German idea, Mr. Hill has evidently the advantage of it, inasmuch as, from cost-estimates we have seen of both plans, Mr. Hill disconnects his runaway horse or horses from the carriage at one-tenth the cost involved by the German competitor. Our woodcut suggests at once Mr. Hill's idea; but although the brake to the hind-wheels is



HILL'S RUNAWAY-HORSE APPARATUS.

not shown, it can be easily added when desired; and this we should certainly recommend, though the elegance of the carriage appearance may be thought to suffer by it. We may here observe that as the same hook forms part of an automatic railway coupling likewise patented by Mr. Hill; and as we intend to illustrate these couplings in a future issue, we do not illustrate the disengaging-hook in detail. By a very slight alteratio in the ordinary carriage-shaft couplings, Hill's apparatus may be substituted; and by carrying a combination of levers to the coachman's box, the latter is enabled to let the shafts loose from the carriage at any time, so allowing the horse to run off by itself. This coupling-hook is so arranged that when in ordinary use, the more the horse pulls, the more the hook fastens itself, so preventing the shafts from loosing at the wrong moment. The reverse takes place when the shafts are required to be detached, for then the pulling-draught of the horse has a tendency to open the clipping-hook, and so liberates both shafts simultaneously. Hill's runaway-horse apparatus is likewise applicable where traces, in place of shafts, are used, such as in pair-horse carriage driving. In this instance it is the traces which are liberated from the carriage-body; but as, even then, the horses would still be attached to the pole through their collar-straps, Mr. Hill substitutes another form of hook at the end of the pole, which hook is so formed as to allow the collar-strap to slip through unimpeded (after the traces of a runaway horse have been loosened) immediately the horse gets in advance of the pole-end. By this contrivance the backing of the carriage at any time, and the holding of the horses abreast, is rendered possible, whilst the forward run of a liberated runaway horse effects his disconnection from the carriage-pole. In conclusion, the lever arrangement to the coachman's box or seat is so arranged as not to be at all interfered with, no matter in what direction the perch-plate might be swivelled, so that the coachman retains at all times entire control over the disconnecting shaft or trace arrangement.

THE TECHNICAL EDUCATION OF THE MECHANICAL ENGINEER.

AMONGST the requirements of knowledge by the mechanical engineer, under which title is meant he who should undertake the direction of mechanical construction, not the least important is, that he should be thoroughly informed in the capability of the handicraft of the workman. The knowledge of the physical properties of bodies, the mathematical propositions of "applied mechanics," the principles and theory of machinery, the construction, form and adaptation of parts in various machines themselves, with the functions they accomplish, can be acquired, to a great degree, by study; but the capabilities of the manipulations of the workshop or workbench will yet remain a mystery, to be unravelled mainly by experience and observation.

In a general sense in the history of mankind, the question of education, or its methods, is not a new one. Each generation, for itself, must be taught and must learn precisely what was learned by the preceding one; and the race in life of the young man will have commenced just when that of his father did. Possibly, sometimes a small increment of knowledge has been gained, and civilization, in its strict meaning of aggregation of people in cities, has taught some one generation lessons in social demands or developments. Education will have followed, and through a series of generations the children will have commenced at a new standpoint, and a new progress in the arts and sciences has been attained. In the arts, this education of the artisan has generally been traditional—from father to son—from master to apprentice; and when, by turbulence and war, the peace-loving and comfortable citizen has been despoiled of his luxuries and comforts by those who have not known enough to create them for themselves, the unrecorded knowledge has been, for a time, lost; to be acquired again, "under protection of the sword." Frequently, the conquerors have protected and employed the workmen, in more or less enslaved conditions; but, with the absence or uncertainty of a free reward, the arts have languished, and have almost, if not entirely perished—carrying with the loss the civilization which originally engendered them, and extending the ruin to the victors themselves. A more stable condition of society, where the soldier has not been the ruler, has, in modern times, guarded and fostered the arts and all derived learning; and the last three or four centuries, whose record we have, or are acquiring, has shown a development and growth of the arts and sciences in unexampled rapidity and magnitude.

The past hundred years alone have witnessed, as seen in the amazing retrospect, the wonderful substitution of machinery for handicraft—of mechanical performance for skilled labour. This has occurred progressively, in the three generations of human life and work which embrace the century, in a kind of geometrical progression for any successive divisions of this period of time

The apprentice of one hundred years since, acquired by experience the teachings of his master, but applied his labour not wholly to the production of the finished article of trade, but in part to the production of machines which were substituted for his hand tools and hand labour. The grown workman, who was fifteen years later the personator of this supposed apprentice, imparted his traditions and acquirements to a new apprentice, who, by the introduction of machinery, was no longer called upon to exercise all the skill, care, or thought that his teacher had been called to employ, because the *machine* had supplemented his tools; another succession and another followed; each time has the machine gained on hand labour, until now the ability of the mechanic consists more in the use of the machine than of the hand. With this progress of mechanism has followed manufacturing, and much of the teaching of the later mechanics has become in the use of special machines confined to distinct processes, to the nearly complete neglect of handicraft or artisan skill. Manufactories and machines have called into existence a new class of skilled workmen, who have learned how to make available, and possess the ability to bring into novel or repeated practice, the acquisitions in mechanical skill of all kinds; and these men are our mechanical engineers.

The distinguished men in the field of mechanical engineering of to-day have grown into these positions. Most of their elementary learning has been derived in the workshop, and from the workman, by the traditional method, and their education has been attained in the experience of failure and success which attends new efforts. The more work a man does, the more mistakes he will make; long years of practice have evolved *types* of machines, each detail of which is an especial result from the labour and intelligence of individual mechanics, and the knowledge of the accomplishment or its methods, yet unrecorded or described, exists only in some directing mind whose capability to apply them constitutes the engineering faculty. The patent records, old and new, cover a small, very small part of the mechanical development of the century—so small that it can almost be said with truth that no valuable machine, process, or apparatus now is, or ever has been covered by any valid or strictly equitable patent claim—so small that these records are never read either as the total of history, or as a complete exposition of any one appliance in mechanism. Descriptive literature is equally at fault in the completeness and practical application of the knowledge which has been gathered in its pages, so that there remains as the only reliable basis of action by the mechanical engineer, only his *appreciation of the capabilities* of materials, both as materials and in manipulation; the latter being either performed by the workman or by the "*machine tool*."

It is easy to see how this knowledge has been acquired by the present holders of it, but it is obvious that the same path is not open to their successors. The large workshops and manufactories have divided labour, in following out their legitimate end of profitable production, until the mechanic in their employment has become the "operative" or overseer of the operations of a machine, with the least of manual or intelligent effort left to humanity. This operative can scarcely be called a workman, and it is very sure that nothing except the possession of the highest mechanical ability will allow him to become an engineer, even if chance gives him an opportunity to develop the ability; and at all events it is certain that the mechanical engineer of the future who shall rival foreign and other competitors in accomplishments, will have learned in another school. Not only is the *operative* of the special machine thus debarred from attainment of knowledge, but the *workmen* in the machine shops, at the smiths' fires, in the pattern room, or the foundry, all in their constancy of labour at their divided branches of industry, are precluded from acquiring general knowledge. Possibly the foreman of a gang of men, or the draughtsman in the office wherein the work is originated, may have the desirable opportunity to witness labour and accomplishment, but the derivation of foremen and of draughtsmen is ceasing to be from the ranks of the operative workman.

Given the educational basis which is now recognized as needful for a civil or mechanical engineer, how is the young man to become a foreman or a draughtsman in the completion of his course of instruction? Given the ability or executive direction which causes a young man to be selected from out of the group

of working operatives to act as foreman; or the mechanical perception which has elevated the youth from the bench to the office desk, how is he to acquire the knowledge of books requisite for him to become a directing engineer? These are the questions to be answered.

There are those who lay great stress upon the value of the old institution of apprenticeship, the return to which is in some way supposed to restore the capability of acquirement of engineering knowledge to the present generation, on a footing similar to that possessed by former ones. This view has been advocated very recently, to such effect that a special Act of the Pennsylvania legislature was passed at the last session (of 1876), offering extraordinary legal safeguards and immunities from responsibility, unknown to the old common law, to manufacturers employing apprentices. If these apprentices shall be really taught as of old in the entire art and mystery of their several occupations, in all that the *master* knows, shall be cared for, bodily and mentally and above all morally, during their apprenticeship, so that when they become journeymen they will (if they have been diligent youths) be fitted to become masters themselves—if not mere labourers—then this law may bear the promise of satisfactory return. But when the obligations here asserted, of equitable apprenticeship upon the masters are admitted, it appears almost certain that the results of this apprentice Act will scarcely fulfil the expectations of some of its advocates and friends.

In every grade of workshop in England, and especially in the engineers' shops (as the machine shops are there denominated), as well as in the offices of the civil engineers, student apprentices or articled pupils are employed. With regard to the former of these, there are many reasons why a similar practice has not been and will not be followed in this country. The first of these reasons is the comparative absence in England of that destructive rivalry in mechanical business which exists in America. The rates for labour, and the estimated value of the mineral in that country, have been so low, and the application of machinery so much in advance (at least until recent years of the century) that England has had the world for a market. The established product of an English workshop has at all times possessed what might be called a goodwill. Few of them will purposely rival, in the same way, another in the production of what is the regular manufacture of the one and but the exceptional demand upon the other; and purchasers are yet more chary in the acceptance of work from inexperienced makers. A man can be generous who has an abundance; he can be just, where he is sure of just dealing in return. Perhaps the condition of abundance has more relevance to the subject under discussion than that of justice. Not many American manufacturers would accept educated, clear-headed, intelligent young men as student apprentices, to learn from their workmen, their machines, and their processes the art and mystery of their business. Beside this, the condition of the student apprentices amongst the workmen in one of our shops may be regarded as too anomalous to the habits of the average American workman or foreman to be supposable in actuality. The second method for obtaining practical experience—that of the articled pupil—suffices in the office of the engineer, but is far from satisfactory as the method to learn the value of the workshop manipulations to the pupil. In this country, at this time, there are no articled pupils, and even students in engineers' offices are rarely to be found.

Neither a return to the system of apprentices and masters, nor the adoption of the method of pupilage in an office, presents the least prospect of affording the education of the business engineer in the future.

The simple question follows, why should not a boy be taught practical mechanics in the school? and this question carries with it its own reply. There is no reason why constructive mechanism should not go hand in hand with applied (mathematical) mechanics, or why manipulation should not be taught at the same time with the properties of materials in the lessons of the school. In accordance with these views, within the past few years, several of our American colleges have established classes and professorships in conjunction with their courses in technical learning. Amongst these, the Sheffield School at Yale College, New Haven, Conn.; the Cornell University at Utica, N.Y.; the Stevens Institute at Hoboken, N.J.; the Free Institute at Worcester, Mass., are prominent examples. Other technical schools have, in different degrees, pursued the handicraft culture of their scholars.

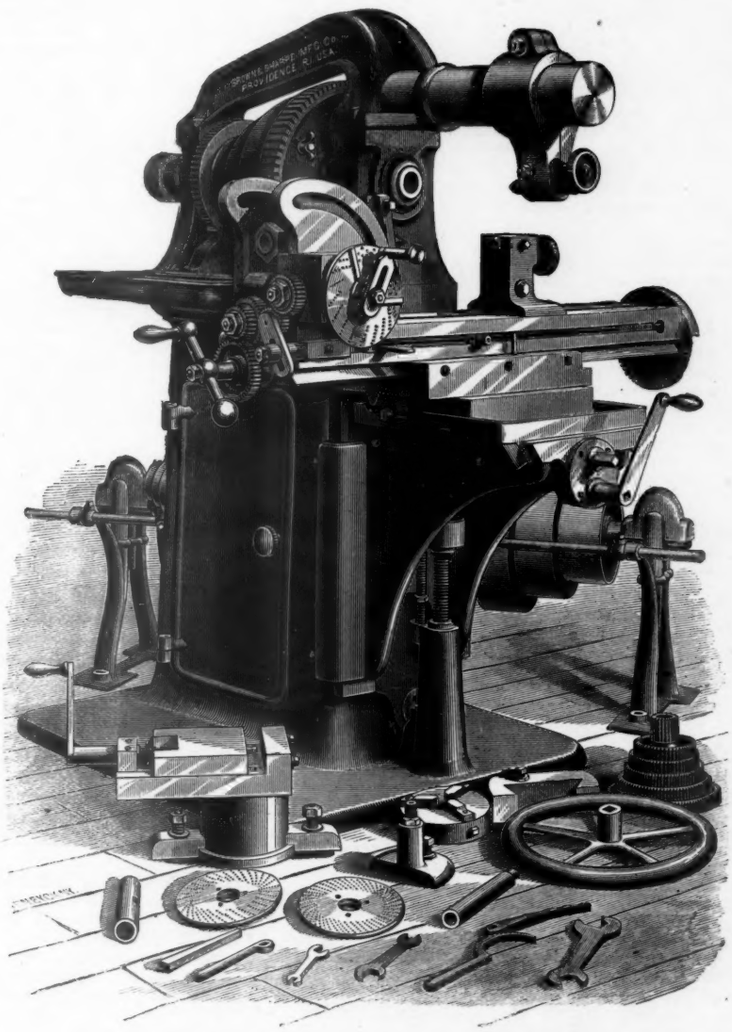
But in thoroughness of teaching, and especially in exhibition of attained success, there is now presented to the admiration of all mechanics, at the Centennial Exhibition, a special example from a foreign land, which should induce emulation. The exhibit made by the Imperial Technical Schools of St. Petersburg and Moscow, demonstrates the feasibility of so educating pupils that when they pass out from the doors of their school, they will have become at once scholars in their learning from books, and proficients as educated workmen in the varied branches of the workshop. These young men on leaving college are quite as able to demand work as journeymen as the average of mechanics when out of their time, for they will have—must have—performed by unaided effort such feats in workmanship, within limited times for accomplishment, as none but skilled workmen can do. The demonstration of the Russian schools is, that this practical instruction can be given in the fullest range and quality, not only without interfering with, but positively to the advancement of other indispensable professional studies. From such an example there should not be the least hesitancy in following the same course in the technical education of the American mechanical engineer. *Journal of the Franklin Institute.*

STRIKES AND THEIR RESULTS.

THE imminence of a dispute between masters and workmen in the pottery trade has given rise to the following practical observations in the "Staffordshire Times." The common-sense nature of the remarks renders them applicable to other industries than that which is the immediate cause of their appearance:—

"There is no longer any doubt with respect to the course intended to be pursued by the master potters. An almost unanimous drop has been decided on, and notices to that effect have been given to the men. This notice has been received with anything but a good grace, and, from appearances, with a determination to resist. To this end meetings have been held by the various branches, with the aim of reviewing their positions and canvassing the feeling of the workmen generally. At one or two of these meetings great feeling has been exhibited, and many idle and unprofitable words spoken. There is nothing got by boasting—a stern silence often shows more strength than airy speech. Nor can the workmen be congratulated on the policy they have thought well to adopt. No sooner have the masters determined on a drop than the men decide on asking for a rise, and, coupled with this, other conditions which the workmen, even were work good now, could only get by a struggle which the potters are in no state to maintain. Any one can see through so shallow and weakly-guided a policy as this. It is easily seen that no rise is expected to be gained, but only to 'stall-off' the intended drop. The masters are not so dull as not to perceive this, and will estimate it at its proper worth. Besides, if the men intend their dispute to be settled by arbitrators, there is no need of a lot of vapouring, as though the matter had to be decided by other means. Before an umpire of an arbitration board all defiant speech counts as nothing, or, if it counts at all, it is so much against those who employ it. No trick of being suddenly smitten with the necessity for a rise on the face of what the other side may think the necessity of a drop will avail them. It is only like a counter-charge, got up for a purpose, and will simply have the appearance and bear the construction of an intention to stop the mouth of the other side. The time that is wasted in foolish and aimless discussions of this character would be better spent if devoted to the fortifying of the present condition and showing why a drop should not be resorted to. To those who think that they are doing this by asking for a rise we beg to point out that they are mistaken. If a man is charged with an assault, and he tries to defend himself by a counter-charge, and has only been instigated to get out a cross-summons simply because he hears that the other side is taking action, it is rarely that anything is got by such a plea, but, what is worse, much time is lost in bringing evidence to support that side of the question which, when the best is done, leaves it as doubtful as it was at first. It would not be proving that there was no assault if it was shown that there were two. In the one case as in the other there would be indecision and tergiversation. Some will hesitate to go in for a rise who would withstand a drop to the last. Never had men a better case than the potters have of maintaining their price, and never did men deserve less to be dropped. If the average wages of a hollow-ware presser are taken they will not reach 24*s.* per week. For this he has to endure heavy and unhealthy labour, and is often from his very calling cut down in his bloom. A flat-presser's wages are even on the average less than this. What militates against this branch of workmen is the wages which they have to pay to their attendants. And whenever their earnings are spoken of they are always referred to in the gross instead of the net. A flat-presser is said to be

able to get 35*s.* or £2 per week. This sum he certainly receives from the office; but then he has to pay his attendants 18*s.* out of it, which brings the man's wages down to a low figure. Much has been said by the potters as to lowering the number of these attendants, fancying it would be to their interest in the end; but this is not always so. We heard the other day of a plate-maker who resolved to try working with one attendant instead of two, and he declared after working all the week his wages were 23*s.*, out of which he had to pay 9*s.* Potters' wages in comparison to the work are becoming less, and for this the masters are a good deal responsible. The sizes are continually on the increase, which makes the work heavier and allows the workman to do less. Take every article almost in hollowware, and it will be found that its growth has been out of all reasonable bounds. The "nines" ewer is now as large as the "fours" was years ago, and so with the chambers, and indeed, so throughout. The flat-pressers have the same cause of complaint, and these features tend very much to make the potter's labour longer and his pay shorter. Let the men address themselves to their real grievance, and show what is the fact of their case, and they will do better than getting up a rise in their lodges which they know will not take place on the factory."



IMPROVED UNIVERSAL MILLING MACHINE.

ONE of the most useful of machines, on account of its adaptation to produce a large range of work in the making of small tools, is the Universal Milling Machine. It is readily applied to the execution of the endless variety of small jobs, which, without it, have to be done in every machine shop by hand labour. The size of milling machines heretofore made has been suitable for the work upon twist drills, mills with spiral or straight teeth, the cutting of small gears, grooving, slotting, and all ordinary operations of milling upon tools usually employed on sewing-machine work and other light machinery, and also by gun-makers.

The machine represented in the illustration is of a larger size, and has been designed specially to meet the wants of steam engine and locomotive builders, and others engaged in the manufacture of heavy machinery, and has important additions to enlarge its range of work. It is provided with an adjustable centre for supporting the end of the arbour carrying the cutters or mills. By the use of gearing upon the head of the machine, it is capable of making very heavy cuts; and the cone is so strongly geared that the machine makes six changes of speed. The antifriction form of spindle and boxes is retained, and both spindle and boxes are of hardened cast-steel, carefully ground, and provided with means of compensation for wear. The carriage moves and is fed automatically, not only at right angles to the spindle, but at any angle, and can be stopped at

any required point. All the motions for producing angles, spirals, and bevels in use upon the smaller machines are applied to this larger size.

The makers are the Brown & Sharpe Manufacturing Company, Providence, R.I., whose agents for this country are Messrs. Churchill & Co., of Wilson Street, Finsbury.

CRANSTON AND LUCK'S PLAN OF CONSERVATORY BUILDING.

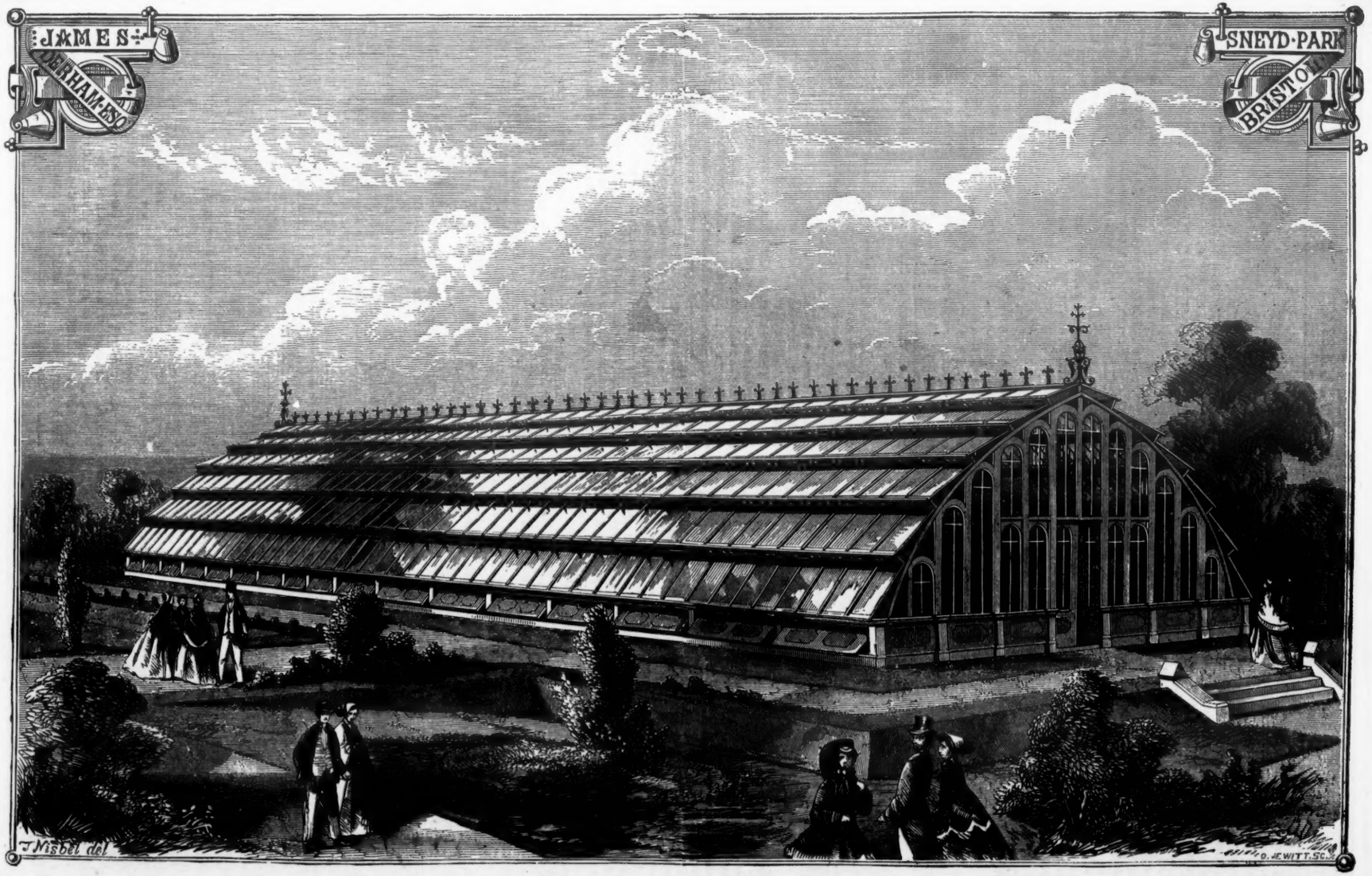
IT is not so long ago that Messrs. Cranston and Luck, of Birmingham, introduced a novel method of building conservatories, orchard-houses, &c., with the chief view of providing better ventilation in such houses. As this construction appears to be likewise applicable to such structures as winter gardens, skating rinks, and aquariums, which are now so much appreciated, we give an illustration of one of these conservatories, which was erected some time ago for James Derham, Esq., of Sneyd Park, Bristol.

The supply of air to all vegetation, where naturally planted, is unlimited, for the wind blows alike over the tiny blade of grass and the sturdy oak; and surely, when plants are changed from the open ground to buildings covered with glass, and facing the sun, they cannot require less air, but, in truth, often demand more. The present buildings, by which an improved system of ventilation is obtained, are composed of the principals, the radial ribs, the bars, the ground planks, the ridges, and the ends—the whole being fitted and screwed together, so that, should it be necessary to pull down and re-erect the house, this can be done without waste of wood or glass, each part being screwed together again as firmly as ever. The illustration will explain the constructive details of this patented principle. It will be seen that the roof is divided into planes of bars and glass, each from 3 to 4 feet deep, which divisions are separated by so-called "radial ribs," fixed edgeways, running from end to end of the buildings under the lower ends of the bottom bars and glass, and between the top and bottom ends of all the others. The peculiarity of the general design consists in these radial ribs, which, irrespective of the shape or size of the corresponding building, are perforated by openings close to each other from end to end. The adjusting of the proper ingress and egress of air from these buildings is effected by a valvular apparatus placed on the inside of these "radial ribs." To the bottom of each radial rib the upper ends of the bars are secured, and the feet of the top bars rest upon the top edge of it. These roof-bars are, moreover, so formed that the glass is firmly held in position without the use of putty; in case of breakage of glass by accident, when putty is used, in ordinary horticultural buildings, it becomes a glazier's job to repair the roof, and each reparation leaves an ugly patch of fresh putty and paint round the new square; but in these patented roofs any gardener can himself replace a broken pane, and leave the roof exactly as it was before. Thus, the external aspect of one of these roofs is a series of planes fitted with glass, divided vertically by small bars, and horizontally by the radial ribs, which are themselves fixed to other timbers put together in the shapes necessary to receive them, spanning the house internally at intervals of from 7 to 8 feet. Again, laps in glass always become black from collecting the dirt, and in damp weather water hangs for a time between the two edges, and so finds its way into the house, or, when frost comes, to freeze and cause the glass to crack and break. Our illustration shows that in all the roof surfaces laps in glass are entirely avoided. By the means used in fixing the large panes of glass in the new roofs, additional strength is given to the glass itself from the solid and even way in which each single pane is bedded upon each of its four edges. In proof of strength, we are informed that the heavy gales of the Atlantic or Irish Sea (to which some of these houses are directly exposed from their situations) have failed to do any damage, even to the breaking of a pane of glass. The efficiency of the perforated radials is, in a great measure, due to the horizontal and projecting positions they occupy in the roofs; for the air, as it travels over the ground, meets the side of the house, and is at once turned from its straight course along one or other of the glass surfaces, to be caught by the overhanging pierced pieces, and conveyed through the many openings in them into the building. The hundreds of small openings in the radial ribs, through which the air passes in as many little streams, each one gently moving and nourishing the plants in its journey through the house, dispelling noxious vapours, and carrying freshness with it everywhere, only represents the breaking up of a strong wind into numberless sections as it travels through the trees and underwood of the hanging coppice, to vivify and strengthen the pet plants in the screened borders. The valves to the perforated radial ribs can be opened or closed in a whole house as quickly as a man can stroll up and down it, and can be limited in extent according to the state of the weather. All the sash bars are made in two parts, triangular in shape, with a small water-gutter on one of the three faces. The lower half of the bar is screwed top and bottom to the lower and upper edges of the radial ventilating ribs with its gutter face upwards; the panes of glass are then laid on with their edges coming up to the sides of the small gutters, and to prevent them slipping down metal clips are fixed to the lower end of the bars, and are turned over the bottom edge of each pane. The other parts of the bars are then put on immediately over those below them, and with their guttered sides downwards; the two half bars are then screwed firmly together, with the glass between them, by three square-headed screws, made and galvanized for the purpose. The upper end of the panes go into grooves in the ventilation plates, and the lower edges rest closely on the top edge of the ventilators below, and here provision is made for the carrying off of water caused by condensation. The half bars, when screwed together, form a water-gutter from end to end, and consequently, if any wet gets in at the edges of the glass, it runs out at the bottom of the grooves, and cannot possibly find its way inside.

Before concluding, we should like to point out the important result obtained, from a horticultural point of view, by which the rays of the sun, at all seasons of the year, must fall directly, and not obliquely, upon some parts of the glass, owing to the divisions of the roof into planes at different angles upon the arched outlines. This patented style of construction, which is at present carried on by Messrs. Cranston and Luck, of Birmingham, is however not merely recommended for conservatory purposes; but the system of perforated horizontal radials, as heretofore described, may be adapted to our living and sleeping rooms. In this case, it is advisable to make the meeting rails of the window-sashes answer all the purposes of the radial ribs, and to do this it is only necessary to perforate the heads of the bottom sashes in a slanting direction from the top, downwards and outwards. Small flaps may then be hung over the openings so formed, which, when opened, should stand up edgeways, parallel with the glass, to direct the fresh air towards the ceiling, so that its temperature may be heightened before it is felt by the occupiers of the apartment. It is said that ventilation through small openings placed in this way in horizontal rows, just above one's head, will neither produce objectionable draughts nor cause the vitiated air next the celling to descend and be re-inhaled. If this statement is absolutely correct, we are evidently one step nearer to the solution of the vexatious ventilation subject.

PRITCHARD, OFFOR, & CO.'S LUBRICATING GREASE.

AT the Royal Show at Birmingham, the machinery in motion, exhibited by Messrs. F. W. Reynolds & Co., was lubricated with the above grease, which worked to perfection. The attention of the railway companies and engineers generally has been actively engaged during the last three or four months in investigating the remarkable qualities of this new lubricant, the peculiarity of which appears to consist in *perfect lubrication throughout the year, and in any climate, without waste.* Some of the results obtained on the English railways appear to be most extraordinary. On the North Staffordshire Railway, the grease has run daily since 13th March, without requiring renewal. On the Manchester, Sheffield, and Lincolnshire Railway, boxes filled on the 11th May have not been touched, and the grease had not gone down half an inch in two months. Similar results on other lines prove that the experience gained in Australia, where this grease was originally manufactured, is fully confirmed in this country, and that the grease will lubricate an axle for 17,500 miles without being touched! Another peculiarity of the grease is said to be that climate does not affect it; *it cannot freeze*, and is therefore wonderfully adapted for Canadian, Russian, and other railways in very cold climates. The confidence of the inventors in the quality of their grease is shown by their offer to provide railways under contract with all the grease required, at a guaranteed saving of



CRANSTON AND LUCK'S PLAN OF CONSERVATORY BUILDING.

25 per cent. in the cost hitherto incurred for this important article. This is good news for shareholders, if vested interests, and the machinery known as "wheels within wheels," do not deprive them of the advantages of the new invention. We are informed that the grease is made of the finest animal and vegetable oils, combined by a secret process. Messrs. P., O., & Co. are also manufacturing a grease to which they give the term of *C* 1, which is a perfect substitute for oil, and is now being extensively used in the principal ironworks, engineering establishments, and factories throughout England and Scotland, and is giving users perfect satisfaction. In some cases, extraordinary results from experiments made with this grease have accrued, 1 lb. (costing 8d. wholesale) having done the same amount of work as one gallon of the finest lubricating oil. The economy in using these greases must be patent to all; but it is not the saving alone which enhances the value of Mr. Pritchard's invention, but what is more important to machinery owners, the bearings, when lubricated with this grease, are kept beautifully cool and clean—one of the greatest desiderata in engineering. *Reynolds' Builders' Trade Circular.*

AMBER.[1]

By M. Reboux.

AMBER was known to the ancients, who made from it ornaments and graven images of their divinities. It was called by the Assyrians *Electra* (*i.e.*, Stone of the Sun), from which the Greeks formed the word *Electron*. The name *Ambre*, from the Arab word *Ambar*, was introduced into France by the Crusaders. This name is less significant than that given to it by the Romans—*Lapis ardens*. The Germans call it *Bernstein*. Amber has been met with in many localities. Formerly it was found upon the sea-shore after storms, and it has also been obtained from the earth. Sicily has produced a large quantity of it, but at the present time the borders of the Baltic supply the entire world.

During the eocene epoch the site of the Baltic Sea was occupied by an immense forest, which covered nearly the whole of the northern continent. There have been obtained by dredging 32 species of conifers, a poplar, an alder, two willows, a chestnut, and some junipers. From these conifers there exuded a resin which underwent a transformation in the bosom of the earth, and became amber. More than a dozen different kinds of objects—animal, vegetable, and mineral—have been found in amber, such as insects, reptiles, pyrites, shells, salt water plants, leaves, seed, fruits, &c.

Amber can be distinguished from copal, or factitious amber, by the following characteristics:—

Copal is of a yellow colour, more or less dark, but always of one colour. At some points of its surface it presents the appearance of crystallized sulphur. Pieces of amber have a different shade at their two extremities.

Amber rubbed upon the palm of the hand exhales a strong aromatic odour. Copal and factitious amber are inodorous.

Amber can be bent under the influence of heat, which is not the case with copal or factitious amber. Copal crumbles under the teeth like dried bread, and can be penetrated by the finger nail. Amber presents more resistance, and can be cut, sawn, or polished. Two pieces of amber cannot be soldered together like two pieces of copal. Amber will scratch copal.

Heated to 100° C., copal gives off the vapour of water in abundance; then it becomes liquid, preserving its yellow colour. Amber does not melt below 400° C., when it becomes black, and gives off a penetrating odour of succinic acid. If 33 per cent. of linseed oil be added, amber melts at 130° C.

A pinch of powdered amber thrown into the light of a candle inflames like gunpowder, giving a bluish flame. Copal gives a pale yellow flame.

Natural amber yields to distillation crystals of succinic acid, which the different copals do not.

The specific gravity varies from 1·09 to 1·11; that of copal is 1·04; that of factitious amber is 1·05.

An analysis of natural amber by Schrotter gave—C, 78·82; H, 10·28; O, 10·90. An analysis of copal from Elæocarpus yielded—C, 79; H, 10·40; O, 9·90.

[1] Extract from a Memoir read before the French Academy ("Comptes Rendus," vol. lxxxii., p. 1374).

Engineering, Building, &c.

ABSTRACTS FROM FOREIGN PERIODICALS.

PROPELLING Lever.—An official trial has been made, at the station of Granollers (Spain), of a lever called "the propelling lever," the object of which is to greatly facilitate the service in stations where there is a considerable movement of carriages. With it a single man may easily manage a truck loaded with a weight of 14 tons, which, without the help of the apparatus, would require the efforts of at least six men. The apparatus is, moreover, simple, consisting of a lever with two branches, one of which, like a hook, rests on the axle-tree, and the other, joined to it by a hinge, works on the periphery of the wheel, giving it a motion of rotation by only raising the lever at the other end.

The application of this ingenious apparatus is not limited to the service of stations. It may, besides, be very useful for the carriages of mines and building works; it is very useful in cases of running off the rails on railways, as well as on tramways, to replace the carriages on the rails; and it is applied with great success in England for easily moving the limbers of guns, and in general all classes of heavy vehicles. *Gaceta Industrial*, 10 *Aug.* 1876.

Bazin's Extractor.—Among the inventions of M. Bazin, of Angers, which have won him a deserved fame, the attention of the engineer is now called to his submarine extractor, which is readily adopted by all nations. Twenty-three of these apparatus work with success in Russia, on the Volga, at Cronstadt, and St. Petersburg; four in North America, viz., one in New York, one in Nevada, one in Colorado, and the other at Gold Bluffs; two of them are used in France, one in French Guiana; forty others have been constructed for various nations, and among them seven for England.

This apparatus is founded: 1. On the principle of the equilibrium of liquids of distinct density in communicating vessels determining an ascensional current due to the hydraulic charge. 2. On a strong counter-current by means of centrifugal pumps, which, while expelling the mixture of water and sand caused by the current produced by the hydraulic charge, gives, however, its contingent of aspiration, being unable to expel without aspiring. In a word, the system of Bazin establishes the relation of those two ascensional causes, or of these two currents, one due to the hydraulic charge and the other to atmospheric pressure.

Practice has proved that 30-horse steam power is sufficient to extract from a considerable depth 4,000 tons of sand in twelve hours of effective work.

The cost of fixing one of these extractors is much less than that of a common dredging machine, the expenses of conservation almost *nil*, and its work is eight or ten times superior to that of a dredging machine with cups. *Porvenir de la Industria*, *Aug.* 4, 1876.

Incombustible Insulators.—The Société Scientifique Industrielle de Marseille has made comparative trials between the incombustible insulator of Pelegrin, represented by M. Costa, and that of the Englishman Leroy, represented in Marseilles by M. Oliva, and other insulators.

The first is white, fine, insoluble, and incombustible; it is composed of amianthus and silicate of soda, is applied in layers of 4 to 6 centimetres (1·57 in. to 2·36 in.) directly upon the iron, to which it adheres, and when, by the dilatation, it separates, it forms a solid rock, very hard, sometimes with crevices, but which never becomes detached.

Leroy's insulator offers few crevices, gives a metallic sound when struck, is of a grey colour, very light, and is applied warm. Water takes away the soluble part of it; but it remains a thick wadding, composed of filamentous matters, upon which a new layer of the composition is applied. *Porvenir de la Industria*, *Aug.* 11, 1876.

Uniformity of Gauge in Railways.—The sleeping carriages which are definitively introduced in France run directly over the lines extending from Paris to the capital of Russia, astonishing many people at their being able to do so when the railways through which they run have not the same gauge. The measures used to obtain this object are most simple, and merely consist of making the wheels slide upon their axle trees, so as to adapt them to the various gauges of the railways which they have to run over. It is practically done in a few minutes, thanks to the arrangements devised by the Prussian

engineers. In our opinion, the latter wished to resolve a problem which this time is connected with their ideas of political preponderance, since their carriages could circulate over all railways in urgent cases, thus liberating themselves from a serious hindrance in military operations. This innovation will afford facilities for traffic, rendering more easy international communication. *Monitor de los Caminos de Hierro, Aug.* 14, 1876.

What Coal Represents.—Everybody knows that mineral coal is the chief aliment of industry, because it represents force condensed in a reduced bulk. With the perfected steam engines which we now possess, a kilogramme of coal represents one hour's work of a horse, or a day's work of a labourer; thus it results that from a ton of coal we can approximately obtain the work of three men during one year's work; and assuming as a basis of our calculations the half of the figure we have just announced, it is perfectly obvious that the 256 millions of tons of coals which are consumed in all the globe by industry replace the work of 400 millions of workmen!

The consumption of coal, as we have repeatedly pointed out in our columns, increases in a notable manner, and it is a product continuously consumed without being reproduced. Fortunately there exist in Europe vast fields, as it happens in Spain, from which only small quantities have been extracted, and in America and elsewhere new mines are frequently discovered, which give hopes of abundant production for the future. Thus, we have not to fear the failing of the combustible which in other times the slow and continuous action of the sun has created for us, storing it in the entrails of the earth; and the only thing which may happen with the lapse of centuries, will be, that our subterranean reserve diminishing in Europe, it will be indispensable to recur to America, Asia, or other countries, the centre of industry being displaced. *Monitor de los Caminos de Hierro*, 28 *Aug.*, 1876.

Aerial Ship.—M. Rablat is now exhibiting in the Casino Cadet the model of an aërial ship to be worked without the help of a balloon or the use of gas lighter than atmospheric air.

The inventor has disposed on each side of his ship three pairs of wings, which are put in motion by an engine placed in the car. The wings, alternately rising and sinking, are constructed of a light frame of rattan and strips of solid stuff; they yield to the pressure of air in the ascending motion, and on the contrary lean on the air in the descending motion, thus reproducing as faithfully as possible the action of the bird's wing.

The construction, both simple and strong, of this aërial ship well deserves the attention of amateurs of aërostation. As to the possibility of raising and managing in the air such an apparatus, we carefully avoid to pronounce an opinion, being in ignorance of the still unknown moving power which is to make wings spreading 12 metres perform an undetermined number of oscillations per minute. *Revue Industrielle, July* 19, 1876.

Malleable Cast-iron.—It is obtained by decarburating common cast-iron; it thus loses its fusing power, but per contra becomes ductile, so as to be able to be soldered. The cast-iron used is by preference wood-smelted; it must be free from phosphorus, sulphur, and silicium, and contain no trace of free graphite. The moulded articles are put in crucibles, where they are surrounded with matters rich in oxygen, such as iron filings, iron ore, &c.; after having carefully stopped the crucibles they are exposed in special ovens to a red temperature during six to eight days. Coke only is to be used for heating the ovens. With this process one is enabled to manufacture articles of very complicated forms, which it would be impossible to obtain with the forge. *Revue Industrielle, Aug.* 9, 1876.

Heating Apparatus.—EDWARD HOFFMAN, of Leipzig, has taken a patent in June last for a novel heating apparatus with gas, which unites the advantages of the oven and of the open fireplace. It consists of an oven fixed in the yard or the cellars of houses, and in it is produced with coal, gas, which is conducted into the rooms by a set of pipes. On opening a tap the gas is introduced into the fire grate, where it is lighted. It is only at issue from the pipes that the gas is mixed with atmospheric air; a peculiar arrangement allows this mixture to be regulated at will, so that a perfect combustion is obtained without production of smoke. When the fireplace is in action, the channels which bring the air are very rapidly heated, thus increasing the usefulness of the apparatus. No danger of explosion is to be feared, since the air is only mixed with the gas at the moment of combustion; even in leaving open, by mistake, the gas pipe, there would be nothing to fear, the efflux running by-and-by up the flue. The products of the distillation are gathered in reservoirs arranged for the purpose along the pipes, whence they may be easily taken away. *Revue Industrielle, Aug.* 16, 1876.

The Interior Sea in Algeria.—At the last meeting of the Académie des Sciences, M. DE LESSEPS presented the summary report of Captain Roudaire on the formation of an interior sea in the African desert.

"We have," said Lesseps, "reason to be satisfied with the results obtained by our learned countryman; it is henceforward certain that it is possible to create a sea with a depth of 25 to 40 metres (13 to 22 fathoms), and which will represent an area of 16,000 kilom. (9,936 miles) with a length of 400 kilom. (242 miles) in the direction from east to west.

"Applying the average rate of salary in Egypt (0 fr. 95 c. for a cubical metre of sand) to the work to be performed to open the new marine lake, the cost of the enterprise will scarcely be over forty millions of francs. Now the income of the fisheries would alone represent an enormous interest for the capital expended, since we see in Egypt the fisheries of the Bitter Lakes produce an income of 1,500,000 fr.

"In this great submersion of the desert none of the oasis would be destroyed. Captain Roudaire has ascertained that the cultivated parts of the desert are all, without exception, 20 metres above the level of the sea." *Revue Industrielle, July* 19, 1876.

Asphalte Mosaic Flooring.—At the Bavarian Industrial Museum may be seen a collection of square tiles of asphalte, prepared by a new process, and intended for floorings, very economical and pleasing to the sight. The tiles are of two various sizes (0m. 80 and 0m. 50 square, and 0m. 02 thick,) and ornamented with mosaic, in white china or coloured glass, which may be arranged according to any design. The manufacture is very simple. The drawing to be reproduced is traced on a sheet of thick paper, which is afterwards covered with the various fragments of china or glass, which will form the mosaic; a border is made to the sheet, and boiling asphalte poured upon it. After the whole is cooled the paper is taken away with cold water, and the tile is prepared.

A flooring covered with such tiles bound together by a string of asphalte appears to have been made by a single melting, and shows a fine appearance. It indefinitely resists damp, and is consequently useful in bath rooms, halls of houses, balconies, &c. A certain number of such appliances have been already made in Vienna and Nuremberg. *Revue Industrielle, Aug.* 23, 1876.

THE PRODUCTIONS OF THE SAMOAN AND NAVIGATOR'S GROUP OF ISLANDS.

THESE islands, which are situated in the South Pacific Ocean from 13° to 15° south latitude, and from 168° to 173° west longitude, have recently been brought into notice from the occurrence of some facts of a political nature. The group is composed of nine islands, the westernmost, Savaii, being the largest; Upolo, the central island, having the largest population, and being the centre of trade and commerce. The port of Apia is the *entrepôt*, where all foreign wares are received and from whence all native products are shipped. The trade is mainly in the hands of large German firms, who have for many years held a monopoly of the cobra trade of the South Pacific Ocean.

"Cobra," the dried meat of the old cocoa-nut, is prepared in large quantities by the natives. It is shipped to Germany, and the oil expressed enters into a combination of valuable soaps used throughout the world. The residue is manufactured into an oil-cake and sold for the feeding and fattening of cattle in Schleswig-Holstein.

The great value of this article and its commercial importance have been cunningly guarded by the Germans, and built up an interest which it is time that England should look to.

The husk of the cocoa-nut from which the cocoa-nut fibre is manufactured has an equal value with the cobra, and will become a great element in the commerce of the islands.

Sea-island cotton of long fibre and great tensile strength was formerly produced by the native population in large quantities. But the Germans, by the importation of foreign labour (a species of terrible slavery) have established plantations throughout the islands, cultivating large quantities of cotton for export. The secretiveness with which this trade has been carried on has aroused the jealous sentiment of Americans, so plainly expressed by recent advices from San Francisco and the tone of the press of the Pacific States of America.

It is well that England, looking to her commercial interest,

should carefully consider a country having an immunity from hurricanes, with five ports—a country teeming with natural products—indigo, sugar, and nutmegs growing wild in abundance—and requiring but the hand of industry to develop resources that are now dormant, and possessing an amiable and industrious population predisposed to the building up of their resources.

The height of the mountain ranges, the watercourses, and the fertile plateaux, with the experiments which have been made, indicate a greater coffee region in the future than Ceylon of to-day. Experiments have proved the great adaptability of soil and climate for the successful production of coffee.

One of the sources of immediate wealth is in the precious woods; forests, having valuable woods of the most enduring texture and capable of receiving a permanent polish, existing throughout the entire group.

Articles as yet unknown to commerce, species of fibre for the manufacturing of cordage and of paper, are as yet untouched.

Is it not well that commercial enterprise take heed of facts which are so pertinently placed before us?

It is to be hoped that reliable information as to the statistics of these islands may be available before long.

DESIGN FOR A SIDEBOARD.

THE massive and handsome sideboard here illustrated is designed by Herr Steffan, architect, of Munich, and has been constructed by a local joiner, Herr Anton. It is made of oak, and being slightly stained and waxed, that dull gloss is imparted to the wood which is so much more pleasing than French polish. The lock-plates or escutcheons are of sheet iron, embossed in parts. Fig. 1 gives the front view; fig. 2, the horizontal section through the cornice, looking upwards; and fig. 3 the side view.

Chemistry applied to the Arts, Manufactures, &c.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF SOCIETIES, ETC.

VARNISH for Glass, which may be written on with common ink or Indian ink, is prepared, according to TERQUEM, speaking before the Trade Association of North France, in the following manner: 4 grs. of mastic in grains, and 8 grs. of sandarach, heated in a *balneum mariæ*, in a stoppered bottle, with 80 grs. of overproof spirit, and afterwards filtrated. On application the glass is to be warmed from 50° to 60° C.; after the writing has been made, the varnish is to be covered with a weak solution of gum. The varnish is very hard, and will appear brilliant and transparent on the heated glass. On cold glass, however, it remains opaque, and will imbibe the ink. Its application is intended for the use of inscriptions on glass bottles, &c. *Stummer's Ingenieur, Aug.* 1876.

Emery Grinding Stones were until now almost exclusively obtained through a mixture of gum, shellac, and emery. When they work with rapidity the shellac is softened, and the grinding stone, becoming greasy, ceases to polish. This difficulty is remedied by using, instead of shellac, soluble glass; this is done in certain German manufactories, the grinding stones of which are not corroded. They may turn at a velocity of 1,000 to 2,000 turns, without losing their form. *Revue Industrielle, Aug.* 9, 1876.

Varnish for Cane and Basket-work.—According to the "Hessischen Gewerbeblatte," lac, prepared after the following recipe, is used to cover split and coloured cane:—25 grs. of good linseed oil are heated in a sand-bath, as long as a drop of it, poured on a cold stone, does not run when the stone is inclined, and when touched with the finger it feels thready. Then are added, first in small portions, 1 lb. fat copal varnish, or some other fat varnish. The heating of the linseed oil must not be carried too far, because otherwise it would not be completely dissolved in the copal varnish, and the vessel wherein the copal varnish is heated must be large, because by the addition of the linseed oil a great deal of frothing takes place. When cold, the required consistence is given to the varnish by mixing it with turpentine oil. It soon dries, preserves a sufficient elasticity, and may be applied with or without addition of colours. *Stummer's Ingenieur, July,* 1876.

Manganic German Silver.—According to the "Berg und hüttenmännische Zeitung," Messrs. BIERMANN and CLODIUS, of Hanover, are making a German silver, which, instead of nickel, contains manganese, and is of the following composition:—Copper, 72·25 parts; manganese, 16·57 parts; zinc, 8·75 parts; iron, 2·43 parts. Such an alloy shows, after being left in water for forty days, no change; it takes a very beautiful plating, and may be easily rolled. It has a somewhat yellow colour.

Alloys for House Bells, &c.—G. E. LICHTENBERGER has been examining alloys used for house bells, distinguished for their white colour, resembling German silver, and their clear, pleasant sound. The analysis of several bells of different sizes was as follows:—

House bell	Copper, 83·22	Tin, 16·76	99·98
Room bell	Copper, 83·09	Tin, 16·80	99·89
Bell for sleigh-bells	Copper, 84·50	Tin, 15·42	99·92
Common yellow bell	Copper, 79·90	Tin, 20·03	99·93

Der Metallarbeiter.

Fastening Tops and Brass Tubes on Gas Lamps.—The following cement is recommended by the "Phönix" for fastening tops and brass cylinders on gas lamps:—4 parts of well-burnt gypsum of isinglass stone and 1 part of gum arabic are mixed together. When wanted for use, some of this mixture is made into a paste by adding water, and the surfaces are coated with it. The article is left to dry at a medium temperature for from eleven to twenty-four hours. *Der Metallarbeiter.*

Colouring Hardened Iron.—The "Phönix" answers the question addressed to it, "What means or procedure are to be used for giving hardened iron the beautiful colour seen on parts of gun-locks?" as follows:—The iron parts, after having been well polished and rubbed dry, are put into a closed box with pure burned leather, and exposed to a steadily burning wood fire. After the box has been standing for about half an hour in a red heat, the contents are turned out into a water tank; the parts are then dried, slightly heated, and coated with benzoin tincture, by means of which the colour obtained receives an especial lustre. *Der Metallarbeiter.*

Blackening Zinc Plates.—The mode of producing a liquid for blackening zinc plates, simplified and recommended by PUSCHER, consists in dissolving equal parts of chlorate of potash and sulphate of copper in 36 parts of water. If the zinc plate, after being scoured bright with diluted muriatic acid and fine quartz sand, is put into the solution for only a few moments, it is covered with a velvety-black coating, adhering very slightly. If it is then quickly and superficially washed with water, left to dry, and then immersed in a dilute solution of asphalte in benzole, the superfluous liquid thrown off, and the plate finally rubbed, after drying, with a pad of cotton wool, to fix the black colour, a zinc plate is obtained which can be highly recommended for roofing and similar purposes. *Deutsch.-Amer. Ind. u. Gew.-Zeit.*, through *Der Metallarbeiter.*

Bronze Colour for Iron.—A good bronze for iron is obtained in the following manner:—Mix 1 part of ivory black, 1 part of chrome yellow, 16 parts of chrome green with undistilled linseed oil, and add some varnish for quicker drying. After the colour is laid on, and about half dry, a very good bronze colour may be produced by putting on the bronze powder with a soft brush on the projecting parts, and rubbing it in with a piece of silk plush. Another good bronze colour may be made by dissolving pulverized gum sandarach in strong potash lye, diluting the solution with water, and causing a precipitation by adding dissolved blue copperas. This green precipitation is washed, dried, and dissolved in oil of turpentine. The product is a fine green varnish, which is not affected by sunlight. *D.-Am. Ind. u. Gew.-Zeit.*, through *Der Metallarbeiter.*

The Lustre of Metals.—Referring to the mode of imparting different lustres to metals mentioned in the "Engineer," the "Metallarbeiter" quotes a procedure recommended by C. PRESCHER ("Jahrbuch der Praktischen Baugewerbe"), who says

XUM

Fig. 1.

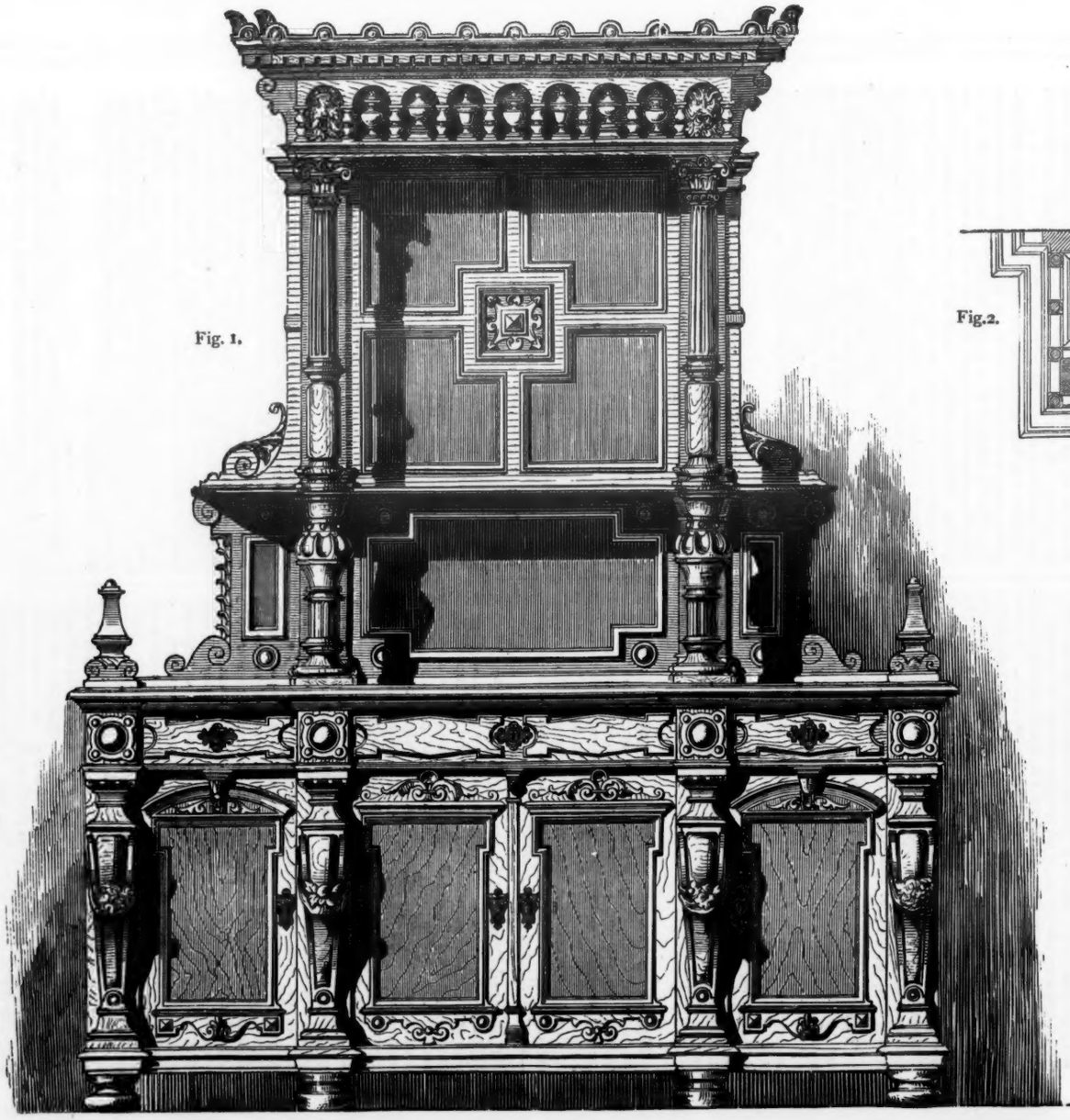


Fig.2.

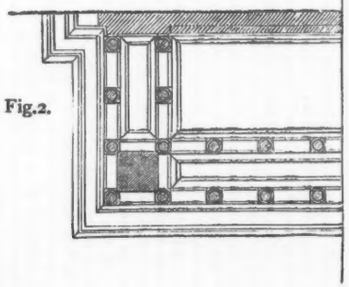
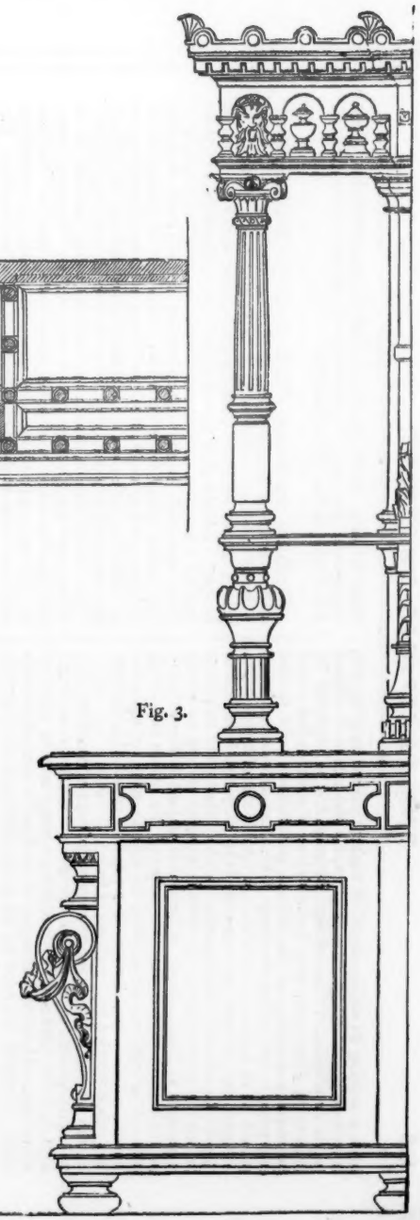


Fig. 3.



DESIGN FOR A SIDEBOARD, BY HERR STEFFAN.

that a coating of sulpho-metal of such thickness may be produced on brass articles as will withstand the action of diluted acids or alkalies. The solution for colouring is produced by dissolving fifty grammes of hyposulphite of soda in half a litre of water, and adding to this sixteen grammes of sugar of lead dissolved in half a litre of water. The clear solution contains, dissolved in hyposulphite of soda, a double salt of hyposulphite of lead and of soda, and possesses the property, if heated to 7°—8° R., of slowly decomposing, and of depositing sulphuret of lead in brown flakes. If there is a metal present such as is contained in brass, a layer of sulphuret of lead is formed on it of the most beautifully lustrous colours. To insure this being effected as uniformly as possible, the articles must be uniformly heated, which is best done by inserting the vessel with the boiling saline solution in a padding of hair.

Iron treated in this manner assumes always a steel-blue, zinc a bronze colour; with copper the golden colour is wanting; lead and tin remain quite indifferent; brass may be coloured any colour. If, instead of sugar of lead, a like quantity of sulphate of copper is added to the soda solution, and the articles are treated as described, brass or Dutch metal is coated beautifully red, followed by green, to change to beautiful brown, with a green and red iridescence. With zinc, the solution gives blackish-brown flakes of sulphuret of copper; if mixed with about one-third of sugar of lead, the colouring becomes black. Marbled designs are obtained with a solution of lead, which, thickened with gum tragacanth, is put on lead-foil heated to 80° Reau., and treated afterwards with the ordinary solution of lead. Similar colourings may also be obtained by antimonial combinations; for instance, tartar emetic. According to Prescher, the colours thus produced are very durable, after the articles to be coloured have first been thoroughly cleaned by acids and lyes; they adhere so firmly that they may be treated with the burnisher.

New Alloy.—An alloy as beautifully white as electro-plate, and at the same time free from expensive nickel, is produced by strongly heating (two to two and a-half hours of brightest red heat) a mixture of one part of best manganese ore in powder, one part of powdered copper scales, with two parts of bone-black. After the lapse of that time, the crucible (a graphite crucible to be preferred) is left to cool, and turned over, when a beautifully white button falls out, along with the unburnt bone-black. This metal may be filed, rolled, and drawn, has a beautiful sound, and seems destined to compete sensibly with nickel and German silver. J. J. HESS, in *Der Metallarbeiter.*

Non-Transparent Varnish.—When black oxydized or such of dead silver articles had to be varnished, it has hitherto not been found possible to do this in an entirely satisfactory manner. A varnish which has proved itself effective consists, according to the "Photographische Archiv," of 18 parts of alcohol, 3 parts of red arsenic, and one part of castor-oil; for especially fine articles it may be diluted with the same amount of alcohol.—*Der Metallarbeiter.*

Coloured Cements fit for Grinding and Polishing.—Dr. S—ky's coloured cements are used to give cast goods of zinc or brass the appearance of buhlwork, and to fill up the holes made by etching in zinc door-plates, street numbers, coats of arms, &c. They are also with advantage employed for making casting-models of more artistic objects, as well as for mosaics on metal ground; but they may further be found useful in engineering works for isolators, larger rings and plates. According to Stach, the following procedure is necessary in their preparation:—A solution of soluble glass of 33° Réau. is mixed with fine whitening, with the addition of the materials mentioned below, until it assumes the tenacity of a thick plastic mass, and thus different coloured cements, hardening in six or seven hours, of considerable strength, and very useful for the purposes above quoted, are obtained. By adding grey sulphuret of antimony a black cement is obtained; this may be polished with agate, and has a metallic onyx-like lustre. Another black cement is prepared by mixing equal parts of sulphuret of antimony and iron filings (finest) with above soluble glass; but this cement can only be ground. Carbonate of copper, pure chrome green, give green; cobalt-blue, blue cements. (Ordinary ultramarine is not fit for use, because it forms Glauber's salt and scatters the mass.) Red lead gives orange cement, sulphide of cadmium citrine, cinnabar bright red, and cochineal-lac violet cement; zinc dust and alcoholized iron give a brown cement, and powdered manganese acts in the same manner. An especially valuable grey cement, which may be polished with the agate to a metallic lustre, and used in the repair of damaged zinc ornaments—whether cast or of sheet zinc—is produced by mixing pure most finely-sifted zinc dust with soluble glass. White cement is made by mixing fine chalk and zinc-white with soluble glass. Hitherto those mixtures have been used solely for imitating marble, but the cements are also of great value in the metalware industry. J. J. HESS, in *Der Metallarbeiter.*

Etching on Glass.—M. E. SEIGWART has lately given some interesting particulars about etching upon glass.

Since fluoric preparations have been produced at reasonable prices, the decoration of glass by their means has steadily made its way. Etched glass is now to be found everywhere, and glass etching runs glass cutting very hard. It is very easy to understand that well etched objects appear actually more beautiful than those which have been cut. The cost of production is cheaper; and since M. Hock, a Viennese chemist, has given us an elaborate work upon the technics of glass etching, the difficulties attending this kind of work have been reduced to a minimum.

As is well known, fluoric acid usually etches smooth, while other fluoric preparations yield a matt surface. The most beautiful ornamentation is obtained when certain parts of the glass surface are rendered matt by means of fluoride of ammonium which has been slightly acidified by means of acetic acid. The matt appearance is not always the same with different kinds of glass, but varies much in beauty; this effect is governed by the composition of the glass, lead glasses being easily acted upon, and furnishing a very fine matt surface.

Where it is desired to have the surface of the glass not altogether matt, but shining like ice, as in the case of window-glass, this may be attained in a simple manner by placing the glass plate in a perfectly horizonal position and covering it with fine groats. Then very dilute fluoric acid is poured upon it. The groats act as a shield, and produce upon the glass raised points.

Several ways exist of etching photographs on glass. A good result may be secured by covering the surface with a solution of gum made sensitive with bichromate of potash, and printing the same under a negative; after the image has been thus produced it is dusted over with minium or red lead, and the red picture thus obtained is fixed and burnt in in the usual manner. The easily soluble red glass so obtained is treated with strong sulphuric acid, when a white matt design is produced, and the picture appears by transmitted light as a positive. *Photographisches Archiv.*

The Radiometer.—In a recent number of "Poggendorff's Annalen," Dr. G. BERTHOLD makes an interesting contribution to the history of the radiometer. It appears that in a paper entitled "Eclaircissement sur le traité physique et historique de l'aurore boréale," published in the Memoirs of the Paris Academy for 1747, M. Mairan gives a description of a light mill. This was a horizontal wheel of iron about 3 in. in diameter, having six radii; at the end of each radius was a small oblique vane. The axis of the wheel was held by its upper point to the end of a magnetic bar. The weight was only thirty grains. Light was concentrated on it with a lens. "Nothing could be more mobile," says M. Mairan, "than this wheel; but at the same time nothing is less certain than the induction one might wish to draw from it in favour of an impulsion by the rays. The machine turns now in one direction, now in the other, according as you bring one of its vanes more or less near to the bars, within or beyond the latter. It is necessary to conclude that the luminous rays attract and repel at different points of the cone which is formed by the lens, but the explosion of a mass of air suddenly and unequally heated round the vane where the focus is applied, appears to me to give a sufficient reason for these effects. The perpetual obstacle of the air naturally suggested to me to make one of these experiments *in vacuo*, but I avow that after having reflected a little on what might be the result I have not thought it worth while taking the trouble." The reasons which thus unfortunately prevented M. Mairan from repeating his experiments *in vacuo* were: (1) the difficulty of producing a sufficient vacuum; (2) the idea, that besides the atmospheric air there was another fluid, which would penetrate the glass and make the experiment doubtful; (3) through action of the burning-glass vapours would rise from the body *in vacuo*, which would, by their impulsion, set it in motion. Dr. Berthold further notices an observation by Michell in Priestley's "History of Optics:" a piece of piano string, 10 in. long, having a square copper plate at one end and a grain of shot at the other, was pivoted in a case having its cover and one side of glass. Solar rays directed from a concave mirror on the copper plate produced repulsion. Priestley considered that this motion must not be attributed to impact of the light rays.

New Galvanic Battery.—M. LECLANCHÉ has just constructed a new galvanic battery, which the "Annales Industrielles" thinks likely to render great service both in manufactures and in scientific research.

The original oxide of manganese battery by the same inventor

consists of a porous jar filled with *pyrolusite*, in which is contained the carbon forming the positive pole. This jar is immersed in a solution of sal ammoniac in contact with zinc. M. Leclanché has, however, introduced several improvements into this battery. He has superseded the porous jar by conglomerating the oxide of manganese, mixed in nearly equal parts with carbon, but with the addition of a small quantity (5 per cent.) of resin for the purpose of giving consistency to the mass. These three substances, properly pulverized and intimately mixed, are conglomerated under a considerable pressure, and at a temperature of about 100° Cent. (212° Fahr.) into a solid cylinder, which serves at the same time as a porous diaphragm and a positive electrode. But here a difficulty occurred. Under the influence of the current, an almost insoluble oxychlorate of zinc was formed, which was deposited in a crystalline form in the pores of the electrode, and considerably diminished its conductibility, so that the internal resistance of the battery increased very rapidly, occasioning considerable inconvenience, especially when used for telegraphic purposes.

M. Leclanché has now got rid of the difficulty by inserting in the centre of the carbon and manganese electrode, while being moulded, a small cylinder of bisulphate of soda. This acid salt prevents the formation of the oxychlorate of zinc; and the battery preserves its regularity for more than a year without the necessity for renewing the water of the saline solution. It offers a much slighter resistance than other batteries, and gives out a considerable quantity of electricity. A single element of small size, presented by M. Du Moncel to the Academy, immediately caused a platinum wire connecting its two poles to become red hot.

Action of the Sulphuret of Carbon, &c.—M. SIDOT repeated before the Société Française de Physique some of his experiments. He shows that charcoal obtained by the action of sulphuret of carbon upon wood heated at a high temperature, possesses a sonority comparable to that of metals; it is also rendered a much better conductor. Cotton, hemp, or paper carbonized in the same manner, are easily rendered incandescent in the flame of gas, but, like the metals, they are extinguished when withdrawn from the flame.

He presents also to the Society the product of the action of light on bisulphuret of carbon. It is protosulphuret of carbon, a solid body, which is deposited in insulated sulphuret of carbon. It contains half less sulphur than sulphuret of carbon, and the remainder of sulphur is found as soluble sulphur dissolved in the liquid not yet resolved.

The hexagonal blende, prepared by displacement at high temperature in a current of sulphurous gas, presents a green phosphorescence of remarkable intensity, which may be very easily observed in daytime, appearing as diffused light, or at night as intense light, like that of magnesium.

Small grains of silver in a bath of sulphuret of carbon, and contained in a matrass stopped with a lamp, are electrized by the agitation of the matrass slightly heated; at the same time sparks are produced inside.

The author also presents samples of magnetic oxide of iron obtained either by combustion of an iron tube, or by calcination of colcothar, and the fragments deposited at the moment of their formation parallel with the dip of the needle have poles placed like those of the needle. *Revue Industrielle, Aug.* 23, 1876.

Artificial Petroleum.—The origin of the enormous store of gas buried in the interior of the earth has not yet been fairly elucidated. Recent experiments presented to the Académie des Sciences by M. BYASSON open the path to knowledge of the reactions which cause its production.

We know, in a general way, that mineral oils are the result of large distillations of ancient or present date, produced in the depth of carboniferous strata. But we absolutely ignore how this result is produced, and all attempts, until now, to form petroleum have utterly failed.

M. Byasson, by projecting on a red-hot iron plate a mixture of carbonic acid and water-steam, has succeeded in determining their combination; he thus produced more than 100 grammes (3·52 oz.) of a mineral essence possessing all the properties of petroleum.

This remarkable experiment, whilst explaining one of the mysterious phenomena of geology, opens for scholars a vast field of experiments by pointing out a new method of manufacturing carburets of hydrogen. *Revue Industrielle, Aug.* 23, 1876.

Hygienic Candles.—Dr. QUARANTE conceived the idea of incorporating with the substances of which candles are made an *antiseptic* one, which, while preserving their lighting power, allows them to purify the often vitiated atmosphere of our apartments and our public rooms.

Impure air contains, among vibrating matter, microscopic insects, spores of cryptogami, infusoria reduced to dust by the desiccation of liquids, bacteriæ, which transmit from man to man all the germs of the numerous diseases to which we are subject. Thus antiseptics have in public hygiene conquered a prominent place, and every locality considered unhealthy is painted or sprinkled with chemical matters deemed likely to destroy unhealthy principles.

Apartments, the air of which is tainted by their inhabitants, almost escape by such sanitary measures. Man is naturally negligent; he would scarcely think to spontaneously make the least effort to purify his apartment; but as he is obliged to have a light when day ceases, it appeared easy and logical to oblige him to render his abode healthy whilst he is lighting it, that is to say, without the least care of any preparation.

For this purpose, in the greasy matter of the lighting candle is incorporated an *antiseptic*, the effects of which are the following: the nearest part of the wick is burnt, supplying oxygen to the wick and increasing the light; the other part dipping in the melting tallow, is volatilized, spreads an inappreciable smell, and destroys the miasma contained in the air.

The density and whiteness of the candle are in no way diminished, and the cheapness of the *antiseptic* allows the hygienic candles to be sold at the same price as the common ones. *Revue Industrielle, Aug.* 30, 1876.

Silvering Metal.—There is, according to Dr. KAYSER, of Nuremberg, a process by which the brilliance of silver may be given to all metals.

Five parts in weight of pure tin and one part of copper are melted together, and the alloy reduced in grains of average fineness. The powder thus obtained is washed in a solution of cream of tartar as pure as possible, and added, with 0·5 per cent. of calcined oxyde of nickel. The article to be silvered is dipped in the bath so obtained, which is carried to boiling point. After some time it is covered with a metallic layer, having quite the outside appearance of silver, and is much more lasting than silver itself. During the operation oxyde of nickel must be from time to time added.

Articles in copper or bronze may be thus silvered without any preparation; but those in iron must be previously galvanized. If some carbonate of nickel is added to the bath, the deposited layer will be richer in nickel, but of a darker colour. By adding a convenient proportion of salt of nickel, it is even possible to obtain the blue-black colour of platinum. *Revue Industrielle, Aug.* 30, 1876.

Carbon di-Sulphide as an Antiseptic.—Herr P. ZOLLER publishes the statement that in an atmosphere containing a small quantity of the vapour of carbon di-sulphide, animal and vegetable matters are effectually preserved against decomposition or putrefaction.

The author affirms that a few drops of this substance is sufficient for the purpose, and since it volatilizes at ordinary temperature, the employment of heat is rendered unnecessary. In this manner, he adds, bread, vegetables, fruit of every kind (and fruit juices), and meat may be preserved for a considerable time in closed vessels. Upon opening the vessels, the unpleasant odour of the di-sulphide is very apparent, but upon airing the substances treated for a few minutes it disappears entirely by volatilization.

In the case of meats, the flesh, after having been submitted to the above treatment for several weeks, is in no wise unpleasantly affected. *Deutsche Industriel Zeitung, Aug.* 24, 1876.

Salicylic Cotton Wadding.—For this purpose a white wadding completely freed from fat by sodium carbonate is necessary. E. RENNARD saturates in a porcelain mortar 10 parts of this wadding with a solution of 2 parts salicylic acid in 15 of alcohol, and 35 of water of 25 to 30° C. (77 to 86° F.). After the solution has been completely absorbed, and uniformly distributed through the cotton, the latter is subjected to pressure until 25 parts of the solution are recovered, which may be used for wetting a fresh portion of cotton. If it is desired to avoid expression, only one part of salicylic acid is employed, but the full quantity of liquid mentioned above, which is about the smallest quantity with which a uniform moistening of the cotton can be effected. The wadding is then dried at ordinary temperature, since a higher heat causes a reddish colour. Thiersch has recommended the addition of some glycerine, in order to fix the acid more permanently upon the cotton; but Rennard states that the addition of 10 and even 20 per cent. of glycerine will not completely prevent the dusting of the acid on beating the cotton. The above proportions furnish a wadding impregnated with 10 per cent. of salicyclic acid; this strength and a wadding containing 4 per cent. are most generally employed. *Zeitsch. Oestr. Ap. Ver.*

Black Venetian Glass.—Articles in black glass made in Venice are distinguished from all similar products by the intensity of their black colour. What is the matter employed to give the glass this colour? M. KAYSER, a chemist of Nuremberg, in order to discover this, made an analysis of a glass known to have been made in Venice, and compared it with black glass, such as is used in the manufacture of Venice beads. This comparison brought out the fact that manganese is the matter employed to give the black colour to glass in which it exists. In fact, while white glass contains only 1·80 of manganic oxyde, black glass contains 11·39, and that is the only notable difference that the two analyses present. To confirm this result, M. Kayser melted in a small furnace a mixture of sand and sulphur, in which he introduced fifteen per cent. of peroxyde of manganese. He thus obtained a glass of a deep black colour; in very fine threads or thin splinters it was of a sombre violet. In one word, it exactly presented, in respect to colour, the same properties as black Venetian glass.

Practical Literature.

ELECTRO-TELEGRAPHY.[1]

WE confess that we are not a little puzzled to discover the reasons which have led Mr. Beechey to compile this volume. He has nothing new to tell us; in fact, he ignores the later views of our eminent scientists on many important points of physics connected with his subject, having apparently never read Professor Clerk Maxwell's writings; and there is nothing in the book which cannot be found in the very excellent work on Telegraphy, recently published in Goodeve's Series of Text Books by Messrs. Preece and Sievewright. It is however only due to our author to say that, while his electrical knowledge certainly does not embrace the results of modern investigation, and his treatment of the subject indicates generally a want of clearness of ideas in connection with electrical science, that portion of his work which deals with the details of telegraphy is written with the skill which a practical knowledge of the subject alone can confer. Within a very small compass he has dealt lucidly and briefly with the salient features of all the telegraphic appliances now in operation, describing their mechanism and manipulation in an interesting and popular style. Submarine telegraphy and some of the more important aspects of telegraphic engineering are touched upon, so that, altogether, the reader who may have had no previous knowledge of the subject may get a good general idea of it—a bird's-eye view, so to speak—from a careful perusal of this book. Its practical utility is, however, far below the work of Messrs. Preece and Sievewright to which reference has already been made, and we cannot help repeating that it would have been better if our author had avoided altogether references to the questions of physical science, and given himself more room to deal with those practical questions of which he is undoubtedly far more competent to treat.

DESIGN AND CONSTRUCTION OF DOCK WALLS.[2]

THE peculiarity of the subject dealt with in this volume—which is undoubtedly a valuable addition to our engineering literature—lies in the fact that, to quote our author, "dock walls may be said to occupy a situation intermediate between masonry dams and retaining walls; the former being built to support a pressure of water, and the latter to resist a thrust of earth. A dock wall has to perform both these functions."

We believe that this practically difficult and theoretically abstruse branch of engineering has not previously been treated of separately, and we are glad therefore to introduce Mr. Allen's book to our readers, trusting that his reward in its compilation will be found, if not in an extensive demand for it—which from the nature of the subject can hardly be hoped for, in the thanks which every engineer who has the construction of such works will accord to him. Books like this, important and valuable as they are, cannot, we imagine, prove remunerative as commercial ventures, but to those engaged in engineering works of the kind treated of they must prove invaluable. We have recently seen a work dealing with a kindred subject to the one before us—a volume of "Tables for Earthwork and Masonry Dams," by Mr. R. C. Anderson—which must have required years of labour and an enormous amount of practical experience in its compilation, and which will be of corresponding value to engineers who have works of the kind to execute, but the sale of which must necessarily be of the most restricted and limited character.

But we are forgetting Mr. Romilly Allen and his book, which has been written in the hope of putting "the engineering student in possession of most of the facts already ascertained and the deductions which have been made therefrom by mathematicians up to the present time." While, of course, much of the information has been culled from the writings of others on the subject, many of the geometrical investigations are now, however, published for the first time. The present volume consists of the theoretical portion of the subject only, the author intending to supplement it by a practical treatise on the materials and appliances used, and the difficulties usually met with by engineers in the construction of dock works. The theory of the construction of dock walls is unfolded in a series of problems, aided by numerous diagrams, reducing the results of theory to practical formulæ, which is preceded by a brief but very clear exposition of the general nature of the forces which come into play and their joint effect upon the works to be executed.

In taking leave of this work, to which we hope we shall have the opportunity of returning at length when the concluding portion of it appears, we would commend to our readers who are interested in the development of this most important branch of engineering enterprise and skill the words of our author, coupling with them (as the toast-masters say) the remark that, if the hint here given were taken and acted upon, results highly important would doubtless be obtained, which would be of immense practical value, and would largely increase our knowledge of one of the most complicated operations which come within the scope of the profession of the civil engineer. He says, after remarking upon the fact that the rule of thumb practical man is now happily disappearing before the rapid strides of scientific advancement, that "it must not, however, be forgotten that it is to practice that theory is indebted for all the data upon which her subsequent reasoning is founded, and that the accuracy of the results obtained will depend entirely on the soundness of these data. *Experiments are also of great value in confirming the results of theory and practice combined, and it is much to be regretted that so few have been tried bearing on this subject.*" The italics are our own.

MACHINERY AND MILL-WORK.[3]

THIS is, as its title indicates, a new and thoroughly revised edition of a work which has long since taken its place as a standard work in the ranks of our practical literature. It is one of the most comprehensive manuals of its kind extant, embracing such important subjects as the "The Geometry and the Dynamics of Machinery, and its Materials, Strength, and Construction," unfolding, as will be seen, both the great laws and principles by which the construction and working of machinery are governed, and the method of putting those laws and principles into action in such a way as to produce the greatest amount of work with a minimum expenditure of energy.

By the student this manual should be prized as an invaluable possession, while all who are concerned in the use and construction of machinery will find it an almost indispensable work of reference.

We should have been glad had space permitted to have entered fully upon the discussion of the various sections of the work, but we are unable to do more than call attention to this new edition, which appears to have undergone a careful and thorough revision. It would, however, have been well, we think, if this edition had been prefaced by a short exposition of the laws of the conservation of energy. This would not have materially increased its bulk, while it would have placed before the student the results of more recent investigation, and would have made him acquainted with the modern theories on a matter which is intimately connected with his studies.

[1] *Electro-Telegraphy.* By Frederic S. Beechey, Telegraph Engineer. London: E. and F. N. Spon, 1876.

[2] *Theory and Practice in the Design and Construction of Dock Walls.* By T. Romilly Allen, Assoc. Inst., C.E. London and New York: E. and F. N Spon, 1876.

[3] *A Manual of Machinery and Mill-Work.* By William John Macquorn Rankine, C.E., &c. With numerous diagrams. Third Edition, thoroughly revised by Edward Fisher Bamber, C.E. London: Charles Griffin and Co., 1876.